



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

MEMORANDUM

Subject: Ecological Risk Management Rationale for Pyrethroids in Registration Review

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Executive Summary

EPA's 2016 ecological assessment of the nine Pyrethroid Working Group (PWG) pyrethroids (bifenthrin, cypermethrin, cyfluthrin, deltamethrin, esfenvalerate, fenpropathrin, cyhalothrin, permethrin, and the pyrethrins) focuses on aquatic organisms, which is the risk driver for these chemicals. This document is intended to serve as a rationale describing EPA's approach in using the current assessment to serve as a basis for making risk management, mitigation, and regulatory decisions for all of the pyrethroids currently undergoing registration review. The aquatic risks in the current assessment for these chemicals are representative of the risks for the non-PWG pyrethroids, also now undergoing registration review. These chemicals include cyphenothrin, d-phenothrin, etofenprox, flumethrin, imiprothrin, momfluorothrin, prallethrin, tau-fluvalinate, tefluthrin, and tetramethrin. All of the pyrethroids have been assessed in the last ten years. Quantitatively assessing the non-PWG chemicals again in the registration review process would give similar results as previous assessments. Risks to mammals and birds have been found for certain pyrethroids in the past. Efforts to mitigate aquatic risks may benefit all taxa.

In the current assessment of the nine PWG chemicals, as expected, there were high acute and chronic listed and non-listed Level of Concern (LOC) exceedances for water column freshwater and estuarine and marine invertebrates for most chemicals, for most uses. For example, for down the drain exposures, risk quotients (RQ's) ranged up to 42.8 (acute) and >464 (chronic). For non-agricultural uses, acute RQ's ranged up to 7,460 (commercial), 3,960 (nursery), and 191 (turf), while chronic RQ's ranged up to >2,220 (commercial), 502 (nursery), and 190 (turf). For agriculture, acute RQ's went up to 62,500 and chronic up to 13,440 for rice, which was an outlier, but otherwise ranged from the single digits to the 1000's. For invertebrates living in benthic sediment, acute and chronic RQ's were lower than water column RQ's, but still had exceedances of the LOC. Exceedances were seen to a lesser extent for freshwater and estuarine and marine fish, and only for some chemicals. A few exceedances were seen for aquatic plants for a few chemicals, with RQ's up to 2.6 for non-agricultural uses, and up to 9.8 for agricultural uses. Pyrethrins had lowest RQ's or no exceedances, while the eight pyrethroids had no clear pattern or consistent outlier among them as far as the highest exceedances.

Previous risk assessments for all pyrethroids show consistent risk to aquatic organisms, and are consistent with the current assessment of the PWG pyrethroids. For mammals, some risk has been identified in past assessments. All of the PWG chemicals previously had at least one acute and chronic non-listed exceedance, particularly for non-agricultural uses, with acute RQs up to 16 for cyfluthrin. There are also some high mammal chronic RQ's for PWG chemicals, generally from Endangered Species Act (ESA) litigation assessments, for example, up to 387 for permethrin. For non-PWG chemicals, most are not toxic or not likely to lead to mammal exposure, except for tefluthrin which is highly toxic to mammals, and had an acute RQ of 16 in a previous assessment. Also, chronic RQ's for tau-fluvalinate and tefluthrin ranged up to 74 and 159, respectively. However, these RQ's were not based on frank reproductive effects, but systemic effects in the reproduction studies.

Avian risk is generally not expected for the pyrethroids. Bird acute RQ's did not or barely exceeded the acute LOC in previous assessments. Most pyrethroids are not toxic to birds or exposure is unlikely. Generally there is no chronic risk to birds, but cyfluthrin and fenpropathrin do have reproductive

effects and RQ's that exceed the LOC. Some chemicals have chronic exceedances based on non-definitive endpoints.

As insecticides, pyrethroids are acutely toxic to bees and other insects. Uses that would result in exposure to bees would be expected to pose an acute risk. The potential for chronic effects to adult bees, and acute or chronic risk to bee larvae, will be assessed once toxicity and exposure data are submitted to the Agency.

Introduction

The pyrethroid class of insecticides along with pyrethrins are currently undergoing registration review under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). EPA has developed a pyrethroid registration review ecological risk assessment strategy that has assessed the pyrethroids as a class, rather than conduct assessments by individual chemical. The assessment focuses on the risks to aquatic organisms due to the well-established evidence of pyrethroid and pyrethrins toxicity to aquatic organisms, which is expected to drive the risk conclusions. This approach was intended to increase efficiency and consistency in assessment methods; ensure that the risks and benefits of these chemicals can be considered against each other and as a class against other classes of pesticides; and to clarify where risks are focused in order to develop meaningful mitigation as a class.

Of the 19 pyrethroids currently undergoing registration review, nine of them were assessed quantitatively in the updated 2016 streamlined pyrethroid ecological risk assessment (hereafter referred to as the current assessment): bifenthrin, cyfluthrin, cyhalothrin, cypermethrin, deltamethrin, esfenvalerate, fenpropathrin, permethrin, and the pyrethrins. These were chosen because the Pyrethroid Working Group (PWG), an industry task force, has generated a large amount of data on these active ingredients, which are predominantly used in agriculture but also have residential and public health uses.

This document accompanies the current assessment and is not intended to be a risk assessment itself, rather this document is intended to:

- Serve as a rationale describing EPA's approach in using the current assessment to serve as a basis for making risk management, mitigation, and regulatory decisions for all of the pyrethroids currently undergoing registration review.
- Describe why risks to aquatic organisms do not need to be reassessed for the non-PWG pyrethroids undergoing registration review.
- Illustrate that the aquatic risks found in the current assessment for the nine PWG chemicals are consistent with the risks found in previous assessments for those chemicals.
- Acknowledge that risks to mammals and birds have been found for certain pyrethroids, and describe why these risks do not need to be assessed for any of the pyrethroids at this time to proceed with potential mitigation.
- Update the risk management strategy for pollinators.

To do this, the uses and exposure routes for the pyrethroids are discussed. The pyrethroids have many uses across agricultural, residential, commercial, indoor and outdoor sites, but can be grouped into broad categories that assist in understanding the potential exposure for those active ingredients that were not quantitatively assessed in the current assessment.

Then, risk conclusions from previous ecological risk assessments are discussed from multiple sources, including the Registration Eligibility Decisions (REDs), Endangered Species Assessments, new use assessments described in the problem formulations completed for registration review, and new use assessments completed since the problem formulations.

Additionally, new data were called in for the pyrethroids under registration review for each active ingredient, including for aquatic taxa. The results of new data conducted for aquatic organisms submitted for registration review, as well as data submitted for other taxa, including mammals, birds, and pollinators, are discussed. Preliminary reviews and completed DERs of studies submitted for aquatic taxa, birds, mammals, and pollinators are consistent with the toxicity profile seen in previous studies. All submitted data for all of the pyrethroids will be reviewed, and applicable DERs will be posted in the public docket concurrent with the issuance of pyrethroid proposed interim decision(s) (PIDs) at a later date.

The pyrethroids that are currently undergoing registration review are presented in Table 1 below:

Table 1. Pyrethrins and pyrethroid insecticides considered in this review.

Active Ingredient	PC code	CAS No.
bifenthrin	128825	82657-04-3
cyfluthrin	128831	68359-37-5
beta-cyfluthrin*	118831	68359-37-5
gamma-cyhalothrin*	128807	76703-62-3
lambda-cyhalothrin	128897	91465-08-6
cypermethrin	109702	52315-07-8
alpha-cypermethrin*	209600	67375-30-8
zeta-cypermethrin*	129064	97955-44-7
cyphenothrin	129013	39515-40-7
deltamethrin	97805	52918-63-5
d-phenothrin	69005	26002-80-2
esfenvalerate	109303	66230-04-4
etofenprox	128965	80844-07-1
fenpropathrin	127901	39515-41-8
flumethrin	036007	69770-45-2
imiprothrin	004006	72963-72-5
momfluorothrin	016331	609346-29-4
permethrin	109701	52645-53-1
prallethrin	128722	23031-36-9
pyrethrins	069001	8003-34-7
tau-fluvalinate	109302	102851-06-9
tefluthrin	128912	79538-32-2
tetramethrin	069003	7696-12-0

* Beta-cyfluthrin is comprised of the same 8 isomers as cyfluthrin, but with the 4 most efficacious isomers enriched; beta-cyfluthrin and cyfluthrin are considered together as cyfluthrins. Similarly, gamma-cyhalothrin is one of the two isomers of lambda-cyhalothrin, and these are considered together as cyhalothrins. Zeta-cypermethrin is comprised of the same 8 isomers as cypermethrin, with the 4 most efficacious isomers enriched, and alpha-cypermethrin contains only 2 of the isomers found in cypermethrin. Together these are considered as cypermethrins.

Description of Uses

The pyrethroids are a class of synthetic insecticides, the first of which, the allethrans, were synthesized in 1948 and are structurally based upon the pyrethrins, which are botanical insecticides extracted from *Chrysanthemum cinerariaefolium* (Soderlund *et. al.* 2002). Pyrethrins are insecticides with relatively low mammalian toxicity, but are sensitive to light, whereas the pyrethroids are more photostable while retaining the insecticidal activity of the pyrethrins.

Pyrethroids and pyrethrins are used widely in a variety of settings, including on many agricultural crops, directly on livestock, and in livestock housing. They are also registered for use on various modes of transportation, including vehicles, ships, airplanes, and trains, as well as in and around structures and buildings including numerous indoor and outdoor residential commercial and industrial spaces. There are also some pyrethroids with registered use on pets and in medical and veterinary products. Permethrin is used in impregnated clothing. There are also several pyrethroids used in wide area Public Health Mosquito abatement programs. Because of the broad range of pests controlled, pyrethroids provide high benefits for many growers and other users, and are an alternative to other types of insecticides, including the neonicotinoids and the organophosphates.

These registered uses can be grouped into use category 'bins'. The bins are presented below, with the active ingredients that fit into each, in Table 2:

Table 2. Pyrethroid insecticides in each use category

Use Category Bin	Active Ingredient
outdoor, structures (residential/commercial including porches, decks)	bifenthrin, cyfluthrins, gamma-cyhalothrin, lambda-cyhalothrin, esfenvalerate, etofenprox, imiprothrin, momfluorothrin, prallethrin, pyrethrins, tau-fluvalinate, tetramethrin
outdoor, impervious surface (residential/commercial patios, paths, walkways, driveways)	bifenthrin, cyfluthrins, lambda-cyhalothrin, deltamethrin, esfenvalerate, pyrethrins, tetramethrin
outdoor, ornamentals and lawns (residential/commercial ornamentals/lawns/turf)	bifenthrin, cyfluthrins, lambda-cyhalothrin, deltamethrin, d-phenothrin, esfenvalerate, fenpropathrin, prallethrin, pyrethrins, tau-fluvalinate, tetramethrin
outdoor - nursery	cypermethrin, alpha-cypermethrin, zeta-cypermethrin, fenpropathrin, permethrin, pyrethrins, tau-fluvalinate, tetramethrin
outdoor - wood treatment	bifenthrin, cyfluthrins, cypermethrin, lambda-cyhalothrin, deltamethrin
outdoor - termiticide (subterranean)	bifenthrin, cyfluthrins, lambda-cyhalothrin, esfenvalerate, permethrin
outdoor non-crop land/rights of way	bifenthrin, cyfluthrins, lambda-cyhalothrin, esfenvalerate
outdoor - animal premise spot/perimeter treatment (livestock or other animal quarters)	bifenthrin, cyfluthrins, deltamethrin, lambda-cyhalothrin

agricultural crops	bifenthrin, cyfluthrins, deltamethrin, cypermethrin, alpha-cypermethrin, zeta-cypermethrin, lambda-cyhalothrin, gamma-cyhalothrin, esfenvalerate, etofenprox, fenpropathrin, permethrin, pyrethrins, tau-fluvalinate, tefluthrin
mosquito adulticide	deltamethrin, etofenprox, permethrin, d-phenothrin, prallethrin, pyrethrins
indoor, down the drain - includes drainage systems/drain pipes/drains/ sewer systems, pet bedding , carpets, animal shampoo/sprays, textiles: upholstery and drapes , bed sheets, spray or impregnated clothes, greenhouse, swimming pool areas	bifenthrin, cyfluthrin, lambda-cyhalothrin, gamma-cyhalothrin, cypermethrin, zeta-cypermethrin, cyphenothrin, deltamethrin, d-phenothrin, esfenvalerate, etofenprox, imiprothrin, permethrin, prallethrin, pyrethrins, tetramethrin
direct livestock application	other livestock: cypermethrin, tetramethrin, permethrin, pyrethrins cattle: lambda-cyhalothrin (ear tags, pour on), gamma-cyhalothrin (pour on)

The nine ‘PWG’ active ingredients that were quantitatively assessed in the current assessment, and the ‘non-PWG’ active ingredients that were not, are well represented in each of these bins. Broadly, the pyrethroids can be then grouped even further into just four use categories related to how they enter the environment. The current EFED risk assessment is organized according to these use groups:

- Indoor uses that can enter waterways via drains (‘down the drain’) and wastewater treatment plants
- Outdoor non-agricultural residential and commercial uses
- Agricultural uses
- Mosquito adulticide wide-area public health uses

These four use groups generally encompass the wide variety of uses found amongst the 19 pyrethroids shown in Table 2. The nine chemicals quantitatively assessed in the current assessment (bifenthrin, cyfluthrins, cyhalothrins, cypermethrins, deltamethrin, esfenvalerate, fenpropathrin, permethrin, and pyrethrins) represent the uses of all 19 pyrethroids. Based upon use, the current assessment can help characterize the potential risks for the other pyrethroids, and risk conclusions for the chemical class can be drawn.

In addition to similar use patterns, the results of the current assessment, which are consistent with past assessments for the 9 PWG chemicals, and the risks identified in past assessments for the other pyrethroids, will be discussed in later sections and further support this approach.

The first part of the current assessment addressed the indoor "down the drain" uses. While there are many indoor uses for the pyrethroids, a subset of uses that EPA believes have a direct exposure path to surface water were quantitatively assessed for the 9 PWG chemicals, as shown in Table 3a.

Table 3a: Indoor Uses of 9 PWG Chemicals, and the Assessed Uses

Active Ingredient	<i>All indoor uses</i>	<i>Assessed “Down the Drain” uses 2016</i>
bifenthrin	bedding, bed frames, box springs, mattress, walls, floors, pet bedding, carpets, drains, greenhouse, surface and space*	bedding, pet bedding, carpets, drains
cyfluthrins	surface and space*, drainage systems, carpet edges	drainage systems, carpet edges
cyhalothrins (gamma and lambda)	bed frames, mattress, box springs, surface and space*, pet bedding, edges of carpets, upholstery, storm drains, sewers, greenhouse, drains	pet bedding, edges of carpets, upholstery, sewers, drains
cypermethrin	surface and space*, draperies, drains, upholstered furniture, pet bedding, rugs/carpets, swimming pool areas	draperies, drains, upholstered furniture, pet bedding, rugs/carpets
alpha-cypermethrin	surface and space*	None
zeta-cypermethrin	bed frames, box springs, mattress, surface and space*, drain pipes/drain/plumbing installations, rug s/carpets, greenhouse	drain pipes/drain/plumbing installations, rugs/carpets
deltamethrin	pet collar, furniture, drains, rugs/carpet, bed frames, box springs, mattress, surface and space*	drains, rugs/carpet
esfenvalerate	bed frames, box springs, mattress, surface and space*, pet bedding, drain system treatments, carpet treatments, furniture, drains, kennels/animal housing areas, structures, grain storage facilities	pet bedding, drain system treatments, carpet treatments, drains
fenpropathrin	none	None
permethrin	bedding, bed frames, box springs, mattress, surface and space*, pet collar, pet spray or dip, treated clothing/impregnated fabric, rugs/carpets, greenhouses, upholstery, clothing, pet bedding, furniture, drapes, sewage and sewer or drain pipe, swimming pool areas	pet spray or dip, treated clothing/impregnated fabric, rug s/carpets, upholstery, clothing, bedding pet/human, drapes, sewage and sewer or drain pipe
pyrethrins	bedding, bed frames, box springs, mattress, surface and space*, pet bedding, upholstery/sofas/chairs, clothing, surface application to rug s/carpet and drapes, carpet edges (bedbugs), pet shampoos/dusts/sprays, sewer lines, swimming pool areas	pet and human bedding, upholstery/sofas/chairs, clothing, surface application to rugs/carpet and drapes, carpet edges (bedbugs), pet shampoos/dusts/sprays, sewer lines

* “Surface and space” includes crack and crevice, walls, floors, fogger, surface and space aerosol sprays, and spot treatments

The indoor uses for the chemicals not quantitatively assessed in the current assessment are shown in Table 3b below.

Table 3b: Indoor Uses of non-PWG Chemicals

Active Ingredient	All indoor uses
cyphenothrin	Spot-on for dogs and horses, dog spray/spot-on, household/domestic dwellings, rug /carpet, storage areas, pet living/sleeping quarters, ships and boats, processing plants
d-phenothrin	mattresses, carpets, sofa-upholstered chairs, non-upholstered chairs, furniture, and other non-porous, non-food contact surfaces, pre-cleaned food-contact surfaces, pet spray and spot-on
etofenprox	bedding, pet spot on, pet bedding/spaces, food areas, upholstery, rugs, carpet
flumethrin	dog/cat collars
imiprothrin	residential, indoor industrial, food handling establishments
momfluorothrin	residential
prallethrin	bed frames, box springs, mattress, surface and space*, pet collar, dog spray or dip, treated clothing/impregnated fabric, rugs/carpets, greenhouses, upholstery, clothing, pet bedding, furniture, drapes, sewage and sewer or drain pipe, swimming pool areas
tau-fluvalinate	none
tefluthrin	none
tetramethrin	surface and space*, indoor non-food areas, animal premises, houseplants

* "Surface and space" includes crack and crevice, walls, floors, fogger, surface and space aerosol sprays, and spot treatments

While the non-PWG chemicals were not quantitatively assessed for down the drain risks (Table 3b), EPA believes that the risks from these chemicals to aquatic organisms are represented in the current assessment, because they have down the drain uses similar to PWG chemicals that were assessed for the same uses. Only four non-PWG chemicals have indoor uses that would be assessed by EFED in a down the drain scenario. Cyphenothrin has carpet uses, d-phenothrin has pet spray, carpet and upholstery uses, etofenprox has rugs/carpet, upholstery, and human/pet bedding uses, and prallethrin has dog spray/dip, treated clothing/impregnated fabric, clothing, rugs/carpets, upholstery, pet bedding, drapes, and sewer/drain pipe uses. These chemicals were not assessed in the current assessment, but they have down the drain uses similar to the PWG chemicals that were assessed for the same uses (Table 3a).

The outdoor non-agricultural uses are shown below. Similar to the indoor uses, there are many outdoor uses for the pyrethroids. A subset of these were assessed in the current assessment scenarios, shown in Table 4a.

Table 4a: Outdoor (Non-Agricultural) uses of 9 PWG Chemicals and Assessed Outdoor uses

Active Ingredient	Outdoor Uses	Assessed Outdoor Uses
bifenthrin	residential, commercial	residential, commercial
cyfluthrins	residential, turf, ornamentals, pets, pet houses, recreational/golf areas, outdoor wood protection	residential, commercial, turf
cyhalothrins (gamma and lambda)	residential, turf, pet living quarters, boats	residential, turf
cypermethrin	residential, commercial, nursery, kennels/livestock facilities, structural termiticide treatments, rights of ways, sanitation (dumps and sewers)	commercial, nursery
alpha-cypermethrin	residential, commercial, nursery, kennels/livestock facilities, structural termiticide treatments, utility areas, irrigation supply systems	commercial, nursery
zeta-cypermethrin	residential, commercial, nursery, kennels/livestock facilities, structural termiticide treatments, rights of ways, sanitation (dumps and sewers)	commercial, nursery
deltamethrin	residential	residential
esfenvalerate	residential, commercial	residential, commercial
fenpropathrin	nursery	nursery
permethrin	residential, commercial, nursery forest trees, ornamentals, pets	residential, commercial, nursery
pyrethrins	wood products, wood surfaces, outdoor - animal premise spot/perimeter/enclosure (including zoos), residential, commercial, turf, nursery	residential, commercial, turf, nursery

Ornamentals, greenhouses may fall into the nursery, residential or commercial categories.

The outdoor uses for the chemicals not quantitatively assessed in the current assessment are shown in Table 4b below.

Table 4b: Outdoor (Non-Agricultural) uses of non-PWG Chemicals

Active Ingredient	All outdoor uses
cyphenothrin	none
<i>d</i> -phenothrin	residential, commercial, public recreational areas, ornamentals
etofenprox	residential, commercial
flumethrin	none
imiprothrin	residential, commercial

Active Ingredient	All outdoor uses
momfluorothrin	residential
prallethrin	residential, commercial
tau-fluvalinate	residential, commercial, turf, nursery
tefluthrin	none
tetramethrin	residential, commercial, nursery, ornamentals

Ornamentals, greenhouses may fall into the nursery, residential or commercial categories.

The non-PWG chemicals that were not included in the current assessment for outdoor non-agricultural uses are represented by the assessed uses (residential, commercial, turf, and nursery) in the current assessment of the 9 PWG chemicals. For example, of the non-PWG chemicals that have uses that were assessed in the current assessment, momfluorothrin has residential uses, d-phenothrin, etofenprox, imiprothrin and prallethrin all have residential and commercial uses, and tau-fluvalinate and tetramethrin all have residential, commercial, turf, and nursery uses.

The agricultural uses are shown below in Table 5a. The pyrethroids are registered for use on a variety of crops. A subset of these uses were identified by the Biological and Economic Analysis Division (BEAD) and assessed in the current assessment, based upon which crops constitute the majority of pyrethroid usage in agriculture and are representative of a diverse set of crop groups, geographic locations, target pests, and agronomic practices, or for which pyrethroid use is particularly important.

Table 5a: Agricultural uses of the 9 PWG Chemicals and Assessed Agricultural Uses

Active Ingredient	Agricultural Uses	Assessed Agricultural Uses 2016
bifenthrin	<i>variety of agricultural commodities including:</i> cucurbit, bushberries, citrus, corn, cotton, soybeans, tree nuts, brassica vegetables, leafy greens, fruiting vegetables, herbs and spices, legumes, and tropical fruit	cucurbit, bushberries, citrus, corn, cotton, soybeans, tree nuts, brassica vegetables, leafy greens
cyfluthrins	<i>variety of agricultural commodities including:</i> alfalfa, bushberries, citrus, corn, cotton, soybeans, sunflower, wheat, fruiting vegetables, brassica vegetables, cucurbits, tobacco, fruit trees, herbs and spices, leafy greens, and nut trees	alfalfa, bushberries, citrus, corn, cotton, soybeans, sunflower, wheat, fruiting vegetables, brassica vegetables, cucurbits
cyhalothrins (gamma and lambda)	<i>variety of agricultural commodities including:</i> alfalfa, cucurbits, citrus, corn, soybeans, sunflowers, wheat, brassica vegetables, fruiting vegetables, rice, fruit trees, nut trees, greens, cotton.	alfalfa, cucurbits, citrus, corn, soybeans, sunflowers, wheat, brassica vegetables, fruiting vegetables, rice
cypermethrin	<i>variety of agricultural commodities including:</i>	alfalfa, bushberries, citrus, corn, cotton, soybeans, sunflower,

Active Ingredient	Agricultural Uses	Assessed Agricultural Uses 2016
	nut trees, brassica vegetables, cotton, root vegetables, blub vegetables, leafy greens,	wheat, fruiting vegetables, brassica vegetables, cucurbits, rice
alpha-cypermethrin	<i>variety of agricultural commodities including:</i> alfalfa, citrus, corn, cotton, soybeans, wheat, fruiting vegetables, brassica vegetables, cucurbits, rice, citrus, nut trees, fruit trees, leafy greens	alfalfa, bushberries, citrus, corn, cotton, soybeans, sunflower, wheat, fruiting vegetables, brassica vegetables, cucurbits, rice
zeta-cypermethrin	<i>variety of agricultural commodities including:</i> bushberries, cucurbits, vegetables, corn, greens, fruit trees, fruiting vegetables, nut trees, citrus, brassica, cotton, sunflower, soy	alfalfa, bushberries, citrus, corn, cotton, soybeans, sunflower, wheat, fruiting vegetables, brassica vegetables, cucurbits, rice
deltamethrin	<i>variety of agricultural commodities including:</i> bulb vegetables, tuberous and corm vegetables, tree nuts, corn, cotton, soybeans, sunflowers, cucurbits, fruiting vegetables, herbs and spices.	bulb vegetables, tuberous and corm vegetables, tree nuts, corn, cotton, soybeans, sunflower, cucurbit, fruiting vegetables
esfenvalerate	<i>variety of agricultural commodities including:</i> brassica vegetables, bushberries, tree nuts, corn, cotton, soybeans, sunflowers, cucurbits, fruiting vegetables, fruit trees	brassica vegetables, bushberries, tree nuts, corn, cotton, soybeans, sunflowers, cucurbits, fruiting vegetables,
fenpropathrin	<i>variety of agricultural commodities including:</i> brassica vegetables, bushberries, citrus, cucurbits, pome fruits, cotton, stone fruits, tree nuts, peanuts, fruiting vegetables	brassica vegetables, bushberries, citrus, cucurbits, pome fruits, cotton, stone fruits, tree nuts, peanuts, fruiting vegetables,
permethrin	<i>variety of agricultural commodities including:</i> alfalfa, bushberries, tree nuts, corn, leafy greens, soybean, brassica vegetables, fruiting vegetables, cucurbits	alfalfa, bushberries, tree nuts, corn, leafy greens, soybean, brassica vegetables, fruiting vegetables, cucurbits
pyrethrins	<i>variety of agricultural commodities including:</i> alfalfa, bushberries, citrus, corn, cotton, soybeans, sunflower, wheat, fruiting vegetables, rice	alfalfa, bushberries, citrus, corn, cotton, soybeans, sunflower, wheat, fruiting vegetables, rice

The agricultural uses for the chemicals not quantitatively assessed in the current assessment are shown in Table 5b below.

Table 5b: Agricultural uses of non-PWG chemicals

Active Ingredient	<i>All agricultural uses</i>
cyphenothrin	none
<i>d</i> -phenothrin	none
etofenprox	rice, citrus, fruit trees
flumethrin	none
imiprothrin	none
momfluorothrin	none
prallethrin	none (tolerances only)
tau-fluvalinate	Special Local Need (SLN) only - crops grown from seed (carrots and brassica)
tefluthrin	corn in-furrow and seed, beet seed
tetramethrin	none

The agricultural section of the current assessment assessed a subset of crops to represent the wide variety of crops for which the PWG chemicals are registered for use. In general, the PWG chemicals are the pyrethroids with agricultural uses. Only three of the non-PWG chemicals have registrations for agricultural uses. Etofenprox has use on rice, fruit trees, and citrus. These uses were assessed for the PWG chemicals and are represented by the current assessment. Tefluthrin has uses on corn, both in-furrow and seed treatments, and on beet seeds. Foliar corn uses were assessed in the current assessment on the PWG chemicals, which would be protective of the furrow and seed treatment uses. In addition, the in-furrow uses for tefluthrin were specifically assessed as a new use (rate increase) in 2016. The beet seed new use was assessed for tefluthrin in 2010. Finally, tau-fluvalinate has a Special Local Need (SLN) FIFRA Section 24(c) registration on carrots and brassica grown for seed, which was assessed in the 2005 RED.

Mosquito Adulticides

There are currently 6 pyrethroid chemicals registered for use as a mosquito adulticide. Of these six chemicals, the three PWG chemicals of this group, deltamethrin, permethrin, and pyrethrins, were assessed in the current assessment for risks associated with this use pattern. Risks associated with this use pattern were not quantitatively assessed in the current assessment for *d*-phenothrin, etofenprox, and prallethrin. The Agency infers that the risks from the assessed PWG chemicals are similar to the risks that would result from those chemicals that were not assessed. Additionally, the chemicals that were not newly assessed have been assessed for this use in the past, and the results of previous assessments are discussed further in this document in the taxa specific risk sections. According to 2012 usage data,

permethrin is a market leading adulticide in terms of treated acreage, along with the organophosphate naled. D-phenothrin is also widely used though to a far lesser degree (Kline and Company, 2013)¹.

Exposure Description

The ecological risk assessment completed for the nine PWG pyrethroids was organized into use groups for which similar assessment methodologies could be used. The indoor "down-the-drain" assessment looked at the indoor uses, and in particular, residues from these uses that had the potential to enter the sewer system and could potentially reach surface water in the environment through the treatment system. For example, this direct link from the use to a sewer system could result from washing treated articles of clothing, washing a pet with a shampoo in the sink, or washing the carpet and disposing of the wash water down the drain. The uses for each chemical in this group are in Table 1a and 1b.

The outdoor non-agricultural assessment assessed risks associated with uses such as lawn, garden, perimeter, and other residential uses, treatments of turf and outdoor premises of commercial buildings, treatments of the outdoor surfaces of the buildings themselves, and treatment of parks and recreational areas. The uses for chemicals in this group are in Table 2a and 2b. The runoff during rain events, particularly from applications to impervious surfaces, has the potential to introduce these chemicals into urban surface water. These uses were assessed using Pesticide Root Zone Model (PRZM) and Variable Volume Water Body Model (VWWM) in the Pesticide Water Calculator (PWC) shell. For most of these uses, a residential watershed with an assumption of 58 lots, each a quarter acre in size, was used to assess exposure from a single application to all lots in the watershed on the same day. Portions of the turf and hard surface in each lot were treated in each assessment. A residential turf and impervious surface scenario were run for each simulation and the two were added together, taking into account the fraction of the total area treated in use to get the total exposure. For example, some uses treat the sides of the house up to three feet off the ground, so the total treated area for each house was estimated and the total was simulated using the impervious surface scenario.

The agricultural uses were also simulated using PRZM and VWWM in the PWC shell to model runoff into waterways from agricultural uses during rain events. In this case the standard scenarios for 13 uses were used and these serve as surrogates for all of the other uses. PRZM is used to simulate application and fate and transport processes in the agricultural field. The total amount of pesticide in runoff water and on eroded sediment is estimated by PRZM and used as loadings into VWWM, which simulates processes in the standard pond, a standard water body used to assess risks for FIFRA assessments of pesticides. The uses for each chemical in this assessment are in Table 3a and 3b.

Mosquito adulticides are intended to remain suspended in air until dissipating, although some residues will reach the ground and surface water. Drift, runoff and soil erosion can lead to exposure.

¹ Kline and Company, 2013. Global Mosquito Control Markets 2012: Market Analysis and Opportunities.

Results of the Current Ecological Risk Assessment of the 9 PWG Chemicals

The ecological assessment on the nine active ingredients (bifenthrin, cypermethrin, cyfluthrin, deltamethrin, esfenvalerate, fenpropathrin, cyhalothrin, permethrin, and the pyrethrins) had risk conclusions that are consistent with past assessments for these chemicals. A description of the results of each section follows below.

Down the Drain

The down the drain section of the assessment found that, as expected, there were acute and chronic listed and non-listed Level of Concern (LOC) exceedances for freshwater and estuarine/marine invertebrates, from indoor down-the-drain exposure to Wastewater Treatment Plants (WWTP's) and Publically Owned Treatment Works (POTWs), which result in releases to bodies of water. The Agency used the EFAST model (2014) to estimate the exposure that would result from these uses. The inputs for this model were determined using proprietary usage data, described in the memo "Pyrethroid and Pyrethrin Usage Data to Support the Down-the-Drain Assessment, DP#426900," dated June 10, 2015.

Acute RQ's exceeded the listed and non-listed LOC for freshwater and estuarine/marine invertebrates that live in the water column for most of the nine assessed active ingredients (except for fenpropathrin, which has no indoor down the drain uses), ranging from 0.07-42.8 (freshwater) and 0.06-5.31 (estuarine/marine). Cyfluthrin exceeded the listed LOC only. Chronic RQ's exceeded the listed and non-listed LOC's for freshwater invertebrates, ranging from 2.0 to >464, and for estuarine/marine invertebrates ranging from 3.8 – 61. Risk to benthic invertebrates was not assessed in this part of the assessment.

Additionally, these uses result in acute risk LOC exceedances for freshwater fish (listed threatened /endangered only) for bifenthrin, *lambda*-cyhalothrin, cypermethrin and esfenvalerate, ranging from 0.06-0.14, plus chronic risk LOC exceedances to freshwater fish for bifenthrin ranging from 3.5-5.3. There are no potential acute or chronic risk LOC exceedances for estuarine/marine fish for the assessed active ingredients. These generalized results are shown in Table 6.

Table 6. Summary of Invertebrate and Fish LOC Exceedances for Down the Drain

Chemical	LOC Exceedances*							
	FW Fish		E/M Fish		FW Inverts**		E/M Inverts**	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Bifenthrin	X	X			X	X	X	X
Cyfluthrin					X	X	X	X
<i>Lambda</i> -Cyhalothrin	X				X	X	X	X
Cypermethrin	X				X	X	X	X
Deltamethrin					X	X	X	X
Esfenvalerate	X				X	X	X	X
Fenpropathrin	No down the drain uses							

Chemical	LOC Exceedances*							
	FW Fish		E/M Fish		FW Inverts**		E/M Inverts**	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Permethrin					X	X	X	X
Pyrethrins					X	X	X	

* An italicized "X" means the RQ exceeds the listed species LOC. A dark shaded and bolded "X" represents an LOC exceedance of the listed species and non-listed species LOC's.

** Invertebrates in the water column.

There were no risks to aquatic plants for any chemical. For cyfluthrin, there is no vascular plant endpoints, and no NOAEC for non-vascular plants. No listed or non-listed acute or chronic LOC's were exceeded for the remaining assessed active ingredients for vascular and non-vascular aquatic plants.

Additional details can be found in the down the drain assessment, "Preliminary Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins Part I. Assessing Pyrethroids Releases to POTW's," dated September 29, 2015.

Outdoor Non-Agriculture

The outdoor non-agricultural section assessed urban residential, institutional and commercial uses of the pyrethroids that occur outdoors, as well as turf, ornamental plant, and nursery uses. The Agency modeled the exposure from the urban uses using the PRZM (Pesticide Root Zone Model) residential, ROW, and impervious surface scenarios separately, with the assumption that no watershed is completely covered by either quarter acre residential lots or undeveloped land, to give the contribution from pervious and impervious surfaces to the exposure. For residential and commercial uses, the maximum labeled rate and one application per year occurring on the same day in a 10 hectare watershed with 58 residential (or commercial) lots were assumed. Turf and nursery uses were modeled with standard scenarios. As expected, risks to aquatic invertebrates are greater than those to fish for both freshwater and estuarine/marine organisms.

The assessment found that there were acute and chronic listed and non-listed LOC exceedances for freshwater and estuarine/marine invertebrates from the residential, commercial, turf and nursery uses for bifenthrin, cyfluthrin, lambda-cyhalothrin, cypermethrin, esfenvalerate, and permethrin. Deltamethrin had similar risks but only had chronic estuarine/marine exceedances for commercial uses. Fenpropathrin had LOC exceedances for the nursery ornamental uses (fenpropathrin does not have outdoor residential or commercial urban uses). Pyrethrins had acute freshwater and estuarine/marine listed LOC exceedances only, for turf, commercial and nursery uses, and a chronic listed and non-listed LOC exceedance for the nursery use.

Benthic (sediment-dwelling) invertebrates tend to be more sensitive to the pyrethroids and pyrethrins than water column dwelling invertebrates, however benthic acute and chronic RQ's were lower than

water column RQ'S. All chemicals, for both pore water and sediment, had acute and chronic listed and non-listed freshwater benthic invertebrate exceedances of the LOC, with the exception of the pyrethrins, which had no exceedances, and cyfluthrin, which had no acute exceedances. The same was true for estuarine/marine invertebrates, with the exception of deltamethrin, which only had acute listed exceedances and one chronic listed and nonlisted exceedance in pore water. Again pyrethrins had no exceedances.

The assessed active ingredients with the most risk concerns for fish were permethrin and bifenthrin. For bifenthrin, there were chronic listed and non-listed exceedances for freshwater fish for turf, residential, and nursery scenarios. Bifenthrin also had acute listed-only LOC exceedances for all uses for freshwater fish. For both freshwater and estuarine/marine fish, there were acute and chronic listed and non-listed LOC exceedances for permethrin for residential scenarios, and listed-only exceedances for turf. For freshwater fish there were also listed and non-listed exceedances for commercial and nursery uses, and for estuarine/marine fish there were acute listed-only exceedances for commercial and nursery uses.

The other chemicals also had exceedances for fish. For esfenvalerate and cyfluthrin, there were acute non-listed freshwater fish exceedances for commercial and nursery scenarios; both chemicals exceeded only the acute listed LOC for freshwater fish for turf and residential uses, and cyfluthrins also exceeded the acute listed LOC for estuarine/marine fish for commercial uses. Cypermethrin exceeded the non-listed acute LOC for freshwater and estuarine/marine fish for only commercial scenarios, and the listed-only LOC for all others. Cyhalothrins exceeded listed and non-listed acute and chronic freshwater fish LOC for nursery scenarios, the acute listed-only LOC for all other uses for freshwater fish, and the acute listed-only LOC for estuarine/marine fish only for nursery uses. Deltamethrin had acute listed-only LOC exceedances for freshwater fish for turf and residential uses, and listed and non-listed acute LOC exceedances for commercial uses for freshwater and estuarine/marine fish. There were no exceedances for pyrethrins.

For most chemicals, there were no risks to aquatic plants. Permethrin had acute exceedances for listed non-vascular plants for some residential and nursely scenarios. Cypermethrin had listed and non-listed exceedances for vascular plants for one residential scenario. For vascular and non-vascular aquatic plants, there is no data available for bifenthrin or pyrethrins, and so no RQ's were calculated. There is no vascular plant data for permethrin or cyfluthrin. No other listed or non-listed acute or chronic LOC's were exceeded for the remaining assessed active ingredients for vascular and non-vascular aquatic plants.

Turf scenario Risk Quotients

Invertebrate acute RQ's that exceeded the listed and non-listed LOC for the assessed active ingredients ranged from 0.63 (cyfluthrins) to 191 (cyhalothrins) for freshwater invertebrates, and from 1.37 (cyhalothrins) to 21 (permethrin) for estuarine/marine invertebrates. Chronic RQ's that exceeded the LOC ranged from 3.9 (cyfluthrin) to 190 (bifenthrin) for freshwater invertebrates, and from 6.5 (esfenvalerate) to 17 (cyhalothrins) for estuarine/marine invertebrates. The acute listed LOC was exceeded for most chemicals for freshwater fish.

No turf scenarios had acute or chronic non-listed chronic exceedances for estuarine/marine fish and there were only chronic exceedances for bifenthrin for freshwater fish, ranging from 1.8-2.0. These generalized results are shown in Table 7.

Table 7. Turf Scenario LOC Exceedances

Chemical	LOC Exceedances*							
	FW Fish		E/M Fish		FW Inverts**		E/M Inverts**	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Bifenthrin	X	X			X	X	X	X
Cyfluthrin	X				X	X	X	X
<i>Lambda</i> -Cyhalothrin	X				X	X	X	X
Cypermethrin	X		X		X	X	X	X
Deltamethrin	X				X	X	X	
Esfenvalerate	X				X	X	X	X
Fenpropathrin	No turf uses							
Permethrin	X		X		X	X	X	X
Pyrethrins					X		X	

* An exceedance denoted in the table indicates that at least one of the turf scenarios resulted in an exceedance of a level of concern (LOC). An italics "X" means the RQ exceeds the listed species LOC. A dark shaded and bolded "X" represents an LOC exceedance of the listed species and non-listed species LOC's.

** Invertebrates in the water column.

Residential and Commercial Scenario Risk Quotients

Invertebrate acute RQ's that exceeded the listed and non-listed LOC ranged from 6.0 (deltamethrin) to 7,460 (cypermethrin) for freshwater invertebrates, and from 1.0 (bifenthrin) to 774 (cypermethrin) for estuarine/marine invertebrates. Chronic RQ's ranged from 1.7 (cyfluthrin) to >2,200 (cypermethrin) for freshwater invertebrates, and ranged from 2.1 (esfenvalerate) to 550 (cypermethrin) for estuarine/marine invertebrates. Pyrethrins exceeded only the acute listed LOC for all invertebrates and the chronic listed and non-listed LOC for freshwater invertebrates.

For fish, acute RQ's that exceeded the non-endangered LOC ranged from 0.67 (lambda cyhalothrin) to 5.7 (cyfluthrin) for freshwater fish, while chronic RQ's ranged from 1.1 (fenpropathrin) to 3.2 (permethrin). For estuarine/marine fish, the acute RQ's ranged from 0.77 (permethrin) to 4.4 (cypermethrin). The only chronic exceedance for estuarine/marine fish was for permethrin, at an RQ of 1.17. These generalized results are shown in Table 8.

Table 8. Residential and Commercial Scenario LOC Exceedances

Chemical	LOC Exceedances*							
	FW Fish		E/M Fish		FW Inverts**		E/M Inverts**	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Bifenthrin	X	X			X	X	X	X
Cyfluthrin	X		X		X	X	X	X
<i>Lambda</i> -Cyhalothrin	X				X	X	X	X
Cypermethrin	X		X		X	X	X	X
Deltamethrin	X		X		X	X	X	X
Esfenvalerate	X				X	X	X	X
Fenpropathrin	X	X			X	X	X	X
Permethrin	X	X	X	X	X	X	X	X
Pyrethrins					X		X	

* An exceedance denoted in the table indicates that at least one of residential and/or commercial uses resulted in an exceedance of a level of concern (LOC). An italics "X" means the RQ exceeds the listed species LOC. A dark shaded and bolded "**X**" represents an LOC exceedance of the listed species and non-listed species LOC's.

** Invertebrates in the water column.

Nursery Scenario Risk Quotients

Invertebrate acute RQ's that exceeded the non-endangered LOC ranged from 4.6 (cyfluthrin) to 3,960 (cyhalothrins) for freshwater invertebrates, and ranged from 0.84 (deltamethrin) to 91.6 (esfenvalerate) for estuarine/marine invertebrates. Chronic RQ's ranged from 1.3 (pyrethrins) to 502 (esfenvalerate) for freshwater invertebrates, and from 1.6 (fenpropathrin) to 479 (cyhalothrins) for estuarine/marine invertebrates.

For fish, acute RQ's that exceeded the non-endangered LOC ranged from 0.81 (deltamethrin) to 11 (cyhalothrins) for freshwater fish and chronic RQ's ranged from 1.6 (bifenthrin and cyhalothrins) to 3.5 (bifenthrin). For estuarine/marine fish, the only acute exceedance was for permethrin, with an RQ of 0.72. There were no chronic exceedances for estuarine/marine fish. These generalized results are shown in Table 9.

Table 9. Nursery Scenario Risk Quotients

Chemical	LOC Exceedances*							
	FW Fish		E/M Fish		FW Inverts**		E/M Inverts**	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Bifenthrin	X	X			X	X	X	X
Cyfluthrin	X				X	X	X	X
<i>Lambda</i> -Cyhalothrin	X	X	X		X	X	X	X
Cypermethrin	X		X		X	X	X	X

Chemical	LOC Exceedances*							
	FW Fish		E/M Fish		FW Inverts**		E/M Inverts**	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Deltamethrin	X		X		X	X	X	X
Esfenvalerate	X				X	X	X	X
Fenpropathrin	X	X	X		X	X	X	X
Permethrin	X	X	X		X	X	X	X
Pyrethrins					X	X	X	

* An exceedance denoted in the table indicates that at least one of the nursery scenarios resulted in an exceedance of a level of concern (LOC). An italics "X" means the RQ exceeds the listed species LOC. A dark shaded and bolded "**X**" represents an LOC exceedance of the listed species and non-listed species LOC's.

** Invertebrates in the water column.

For a full description of the models, inputs, assumptions, and results, see the EFED assessment titled "Preliminary Comparative Environmental Fate and Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins Part II. Assessing Outdoor Urban Uses of Pyrethroids," dated May 20, 2016.

Agriculture

The pyrethroids have many and diverse agricultural uses. Of these uses, a subset were identified by the Biological and Economic Analysis Division (BEAD) as consisting of the vast majority of the usage and to be representative of a diverse set of crop groups, geographic locations, target pests, and agronomic practices. The predominant crops are alfalfa, corn, sweet corn, cotton, soybean, sunflowers, wheat and rice. EFED modeled these uses using aerial applications where applicable as the maximum use scenario. Rice uses were modeled separately. In addition, other crops that may have less usage but where pyrethroids are important to that crop were also modeled, including one vegetable crop (e.g., cucurbit vegetables, fruiting vegetables, or brassica (head and stem) vegetables), one specialty crop (blueberries), and one tree that could be applied using air blast methods of application (citrus fruits).

Selected agricultural scenarios were modeled in the Pesticide Water Calculator (PWC) in which exposure concentrations for surface waters assessments are estimated based on EFED's Tier II aquatic models, the Pesticide Root Zone Model (PRZM) and Varying Volume Water Body Model (VWWM). EECs were determined using the standard pond scenario which describes a vulnerable surface water scenario for the VWWM component of the modeling exercise. The Pesticide in Flooded Application Model (PFAM) was used to model the rice uses of the cypermethrins, cyhalothrins and pyrethrins. The maximum application rate, number of applications and minimum interval between applications were modeled. Results for non-listed aquatic species in the water column are discussed below.

For freshwater fish, the highest acute and chronic non-listed LOC exceedances were seen generally on rice, grapes/blueberries, and cotton. For pyrethrins, non-listed acute LOC exceedances were seen but only for rice (RQ of 11). LOC exceedances were also seen for deltamethrin (RQ up to 5, on cotton),

permethrin (up to an RQ of 7, for grapes/blueberries), esfenvalerate (RQ's up to 8.80, for cotton), cypermethrin (RQ's up to 10, for rice), cyfluthrin (RQ's up to 10.1, for cotton), lambda cyhalothrin (RQ of 172 for rice - otherwise the highest RQ was 26 for cotton), and fenpropathrin (RQ's up to 1.7, on cotton). Chronic exceedances were seen for pyrethrins but only for rice (RQ of 1.5), bifenthrin (RQ of 3.5 for all crops, due to the limit of solubility), permethrin (up to 23, for grapes/blueberries), esfenvalerate (RQ's up to 2.2, for cotton), cypermethrin (RQ's up to 8, for rice), cyfluthrin (RQ's up to 3.3, for cotton), lambda cyhalothrin (RQ's up to 7.4, for rice), and fenpropathrin (RQ's up to 5.2, on cotton). There were no acute or chronic exceedances for deltamethrin. These generalized results are shown in Table 10.

Table 10. Agricultural Scenario Risk Quotients for Freshwater Fish

Chemical		LOC Exceedances*													
		Alfalfa	Grapes/ blueberries	Tree nuts	Citrus	Corn	Sweet Corn	Cotton	Soybean	Sunflower	Wheat	Fruiting vegetable	Cucurbit	Cole	Rice
Bifenthrin	Acute	NA	X	X	X	X	X	X	X	NA	NA	NA	X	X	NA
	Chronic	NA	X	X	X	X	X	X	X	NA	NA	NA	X	X	NA
Cyfluthrin	Acute	X	X	NA	X	X	X	X	X	X	X	X	X	X	NA
	Chronic	-	X	NA	X	X	X	X	X	-	-	X	X	X	NA
<i>Lambda-Cyhalothrin</i>	Acute	X	NA	NA	X	X	X	X	X	X	X	X	X	X	X
	Chronic	X	NA	NA	X	X	X	X	X	X	-	X	X	X	X
Cypermethrin	Acute	X	X	NA	X	X	X	X	X	X	X	X	X	X	X
	Chronic	-	-	NA	-	-	-	-	-	-	-	-	-	-	X
Deltamethrin	Acute	NA	NA	X	NA	X	X	X	X	-	NA	X	X	NA	NA
	Chronic	NA	NA	-	NA	-	-	-	-	-	NA	-	-	NA	NA
Esfenvalerate	Acute	NA	X	X	NA	X	X	X	X	X	NA	X	X	X	NA
	Chronic	NA	X	X	NA	X	-	X	-	-	NA	-	-	X	NA
Fenpropathrin	Acute	NA	X	X	X	NA	NA	X	NA	NA	NA	X	X	X	NA
	Chronic	NA	X	X	X	NA	NA	X	NA	NA	NA	X	X	X	NA
Permethrin	Acute	X	X	X	NA	X	X	NA	X	NA	NA	X	X	X	NA
	Chronic	X	X	X	NA	X	X	NA	X	NA	NA	X	X	X	NA
Pyrethrins	Acute	X	X	NA	X	X	X	X	X	X	X	X	NA	NA	X
	Chronic	-	-	-	-	-	-	-	-	-	-	-	-	-	X

* An exceedance denoted in the table indicates an exceedance of a level of concern (LOC) for that crop. An italics "X" means the RQ exceeds the listed species LOC. A dark shaded and bolded "X" represents an LOC exceedance of the listed species and non-listed species LOC's.

** Invertebrates in the water column.

NA – Crop is not applicable/not assessed for the chemical. Not all assessed crops are included in the table, only the most commonly assessed crops across chemicals. As a result some chemicals have additional exceedances not shown here.

For estuarine/marine fish, the same crops produced the highest acute and chronic exceedances. Acute LOC exceedances were seen for pyrethrins only for rice (RQ of 3.5). LOC exceedances were seen for permethrin (RQ's up to 2.5, for grapes/blueberries), cypermethrin (RQ's up to 4.2, for rice), lambda cyhalothrin (RQ of 6.20, for rice - otherwise the only other exceedance was for cotton at 0.92), and fenpropathrin (RQ's up to 1.2, on cotton). Chronic exceedances were seen for pyrethrins only for rice (RQ of 4.0), and for permethrin (RQ's up to 8.53, for grapes/blueberries), and cypermethrin (RQ's up to 3.3, for rice). There were no nonlisted acute or chronic exceedances for bifenthrin, cyfluthrin, deltamethrin, or esfenvalerate; however deltamethrin, cyfluthrin and esfenvalerate did exceed the acute listed LOC. These generalized results are shown in Table 11.

Table 11. Agricultural Scenario Risk Quotients for Estuarine/Marine Fish

Chemical		LOC Exceedances*													
		Alfalfa	Grapes/ blueberries	Tree nuts	Citrus	Corn	Sweet Corn	Cotton	Soybean	Sunflower	Wheat	Fruiting vegetable	Cucurbit	Cole	Rice
Bifenthrin	Acute	NA	-	-	-	-	-	-	-	NA	NA	NA	-	-	NA
	Chronic	NA	-	-	-	-	-	-	-	NA	NA	NA	-	-	NA
Cyfluthrin	Acute	-	X	NA	X	X	-	X	-	-	-	X	X	X	NA
	Chronic	-	-	NA	-	-	-	-	-	-	-	-	-	-	NA
Lambda-Cyhalothrin	Acute	X	NA	NA	X	X	X	X	X	X	X	X	X	X	X
	Chronic	-	NA	NA	-	-	-	-	-	-	-	-	-	-	-
Cypermethrin	Acute	X	X	NA	X	X	X	X	X	-	X	X	X	X	X
	Chronic	-	-	NA	-	-	-	-	-	-	-	-	-	-	X
Deltamethrin	Acute	NA	NA	X	NA	X	X	X	X	-	NA	X	X	NA	NA
	Chronic	NA	NA	-	NA	-	-	-	-	-	NA	-	-	NA	NA
Esfenvalerate	Acute	NA	X	X	NA	-	-	X	-	-	NA	-	-	-	NA
	Chronic	NA	-	-	NA	-	-	-	-	-	NA	-	-	-	NA
Fenpropathrin	Acute	NA	X	X	X	NA	NA	X	NA	NA	NA	X	X	X	NA
	Chronic	NA	-	-	-	NA	NA	-	NA	NA	NA	-	-	-	NA

Chemical		LOC Exceedances*													
		Alfalfa	Grapes/ blueberries	Tree nuts	Citrus	Corn	Sweet Corn	Cotton	Soybean	Sunflower	Wheat	Fruiting vegetable	Cucurbit	Cole	Rice
Permethrin	Acute	X	X	X	NA	X	X	NA	X	NA	NA	X	X	X	NA
	Chronic	-	X	X	NA	-	-	NA	-	NA	NA	-	-	-	NA
Pyrethrins	Acute	-	X	NA	-	X	-	X	X	-	-	X	NA	NA	X
	Chronic	-	-	NA	-	-	-	-	-	-	-	-	NA	NA	X

* An exceedance denoted in the table indicates an exceedance of a level of concern (LOC) for that crop. An italic "X" means the RQ exceeds the listed species LOC. A dark shaded and bolded "**X**" represents an LOC exceedance of the listed species and non-listed species LOC's.

NA – Crop is not applicable/not assessed for the chemical. Not all assessed crops are included in the table, only the most commonly assessed crops across chemicals. As a result some chemicals have additional exceedances not shown here.

For both freshwater and estuarine/marine invertebrates, the highest acute and chronic exceedances were seen for the same crops as were seen for fish. Acute and chronic LOC exceedances were seen for all assessed chemicals for invertebrates. For freshwater invertebrates, the acute RQ that exceeded the LOC for bifenthrin was 28.4 for all crops (due to the limit of solubility). For deltamethrin, acute RQ's were as high as 1000 (cotton), up to 830 for permethrin (grapes/blueberries), and up to 1470 for esfenvalerate, on cotton. RQ's were up to 1675 for cypermethrin, (grapes/blueberries), with an outlier RQ of 7090 for rice. RQ's were up to 29 for cyfluthrin (cotton), and up to 1213 for fenpropathrin, on cotton. For pyrethrins the highest RQ was 74 for rice but otherwise ranged up to 2.2 (grapes/blueberries). RQ's were up to 9250 for lambda cyhalothrin (cotton) and there was an RQ of 62,500 for rice.

The freshwater invertebrate chronic RQ's that exceeded the LOC for bifenthrin was 280 (due to the limit of solubility). The chronic RQ's for deltamethrin went up to 490 (cotton), up to 329 for permethrin (grapes/blueberries), up to 1420 for esfenvalerate (cotton), up to 194 for cyfluthrin (cotton), and up to >229 for fenpropathrin, on cotton. For pyrethrins the RQ was 115 for rice, and otherwise ranged up to 24 (grapes/blueberries). RQ's ranged up to >1124 for cypermethrin (grapes blueberries), and there was an RQ of >13,440 for rice. RQ's ranged up to 1,082 for lambda cyhalothrin, on cotton, and there was an RQ of 1,750 for rice. These generalized results are shown in Table 12.

Table 12. Agricultural Scenario Risk Quotients for Freshwater Invertebrates (water column)

Chemical		LOC Exceedances*													
		Alfalfa	Grapes/ blueberries	Tree nuts	Citrus	Corn	Sweet Corn	Cotton	Soybean	Sunflower	Wheat	Fruiting vegetable	Cucurbit	Cole	Rice
Bifenthrin	Acute	NA	X	X	X	X	X	X	X	NA	NA	NA	X	X	NA
	Chronic	NA	X	X	X	X	X	X	X	NA	NA	NA	X	X	NA
Cyfluthrin	Acute	X	X	NA	X	X	X	X	X	X	X	X	X	X	NA
	Chronic	X	X	NA	X	X	X	X	X	X	X	X	X	X	NA
<i>Lambda</i> -Cyhalothrin	Acute	X	NA	NA	X	X	X	X	X	X	X	X	X	X	X
	Chronic	X	NA	NA	X	X	X	X	X	X	X	X	X	X	X
Cypermethrin	Acute	X	X	NA	X	X	X	X	X	X	X	X	X	X	X
	Chronic	X	X	NA	X	X	X	X	X	X	X	X	X	X	X
Deltamethrin	Acute	NA	NA	X	NA	X	X	X	X	X	NA	X	X	NA	NA
	Chronic	NA	NA	X	NA	X	X	X	X	X	NA	X	X	NA	NA
Esfenvalerate	Acute	NA	X	X	NA	X	X	X	X	X	NA	X	X	X	NA
	Chronic	NA	X	X	NA	X	X	X	X	X	NA	X	X	X	NA
Fenpropathrin	Acute	NA	X	X	X	NA	NA	X	NA	NA	NA	X	X	X	NA
	Chronic	NA	X	X	X	NA	NA	X	NA	NA	NA	X	X	X	NA
Permethrin	Acute	X	X	X	NA	X	X	NA	X	NA	NA	X	X	X	NA
	Chronic	X	X	X	NA	X	X	NA	X	NA	NA	X	X	X	NA
Pyrethrins	Acute	X	X	NA	X	X	X	X	X	X	X	X	NA	NA	X
	Chronic	X	X	NA	X	X	X	X	X	X	X	X	NA	NA	X

* An exceedance denoted in the table indicates an exceedance of a level of concern (LOC) for that crop. An italicized "X" means the RQ exceeds the listed species LOC. A dark shaded and bolded "X" represents an LOC exceedance of the listed species and non-listed species LOC's.

NA – Crop is not applicable/not assessed for the chemical. Not all assessed crops are included in the table, only the most commonly assessed crops across chemicals. As a result some chemicals have additional exceedances not shown here.

For estuarine/marine invertebrates, the acute RQ that exceeded the LOC for bifenthrin was 3.5 for all crops (due to the limit of solubility). The acute RQ's for deltamethrin ranged up to 54 (cotton), up to 310 for permethrin (grapes/blueberries), up to 268 for esfenvalerate (cotton), up to 331 for cyfluthrin (cotton), and up to 176 for fenpropathrin, on cotton. For pyrethrins the RQ was 40 for rice but otherwise

ranged up to 0.68, for grapes/blueberries. The RQ's ranged up to 174 for cypermethrin (grapes blueberries) and there was an RQ of 735 for rice. RQ's were as high as 151 for lambda cyhalothrin, on cotton, and there was an RQ of 1,020 for rice.

The estuarine/marine invertebrate chronic RQ that exceeded the LOC for bifenthrin was >23 (due to the limit of solubility). The acute RQ's for deltamethrin ranged up to 27 (cotton), up to 580 for permethrin (grapes/blueberries), up to 258 for esfenvalerate (cotton), up to 333 for cyfluthrin (cotton), and up to 29 for fenpropathrin on cotton. For pyrethrins the RQ was 18 for rice, but otherwise ranged up to 3.8, for grapes/blueberries. RQ's ranged up to 281 for cypermethrin (grapes/blueberries) and there was an RQ of 3,360 for rice. RQ's were as high as 1190 for lambda cyhalothrin, on cotton, and there was an RQ of 1,930 for rice. These generalized results are shown in Table 13.

Table 13. Agricultural Scenario Risk Quotients for Estuarine/Marine Invertebrates (water column)

Chemical		LOC Exceedances*													
		Alfalfa	Grapes/ blueberries	Tree nuts	Citrus	Corn	Sweet Corn	Cotton	Soybean	Sunflower	Wheat	Fruiting vegetable	Cucurbit	Cole	Rice
Bifenthrin	Acute	NA	X	X	X	X	X	X	X	NA	NA	NA	X	X	NA
	Chronic	NA	X	X	X	X	X	X	X	NA	NA	NA	X	X	NA
Cyfluthrin	Acute	X	X	NA	X	X	X	X	X	X	X	X	X	X	NA
	Chronic	X	X	NA	X	X	X	X	X	X	X	X	X	X	NA
Lambda-Cyhalothrin	Acute	X	X	NA	X	X	X	X	X	X	X	X	X	X	X
	Chronic	X	X	NA	X	X	X	X	X	X	X	X	X	X	X
Cypermethrin	Acute	X	X	NA	X	X	X	X	X	X	X	X	X	X	X
	Chronic	X	X	NA	X	X	X	X	X	X	X	X	X	X	X
Deltamethrin	Acute	NA	NA	X	NA	X	X	X	X	X	NA	X	X	NA	NA
	Chronic	NA	NA	X	NA	X	X	X	X	X	NA	X	X	NA	NA
Esfenvalerate	Acute	NA	X	X	NA	X	X	X	X	X	NA	X	X	X	NA
	Chronic	NA	X	X	NA	X	X	X	X	X	NA	X	X	X	NA
Fenpropathrin	Acute	NA	X	X	X	NA	NA	X	NA	NA	NA	X	X	X	NA
	Chronic	NA	X	X	X	NA	NA	X	NA	NA	NA	X	X	X	NA
Permethrin	Acute	X	X	X	NA	X	X	NA	X	NA	NA	X	X	X	NA
	Chronic	X	X	X	NA	X	X	NA	X	NA	NA	X	X	X	NA
Pyrethrins	Acute	X	X	NA	X	X	X	X	X	X	X	X	NA	NA	X

Chemical		LOC Exceedances*													
		Alfalfa	Grapes/ blueberries	Tree nuts	Citrus	Corn	Sweet Corn	Cotton	Soybean	Sunflower	Wheat	Fruiting vegetable	Cucurbit	Cole	Rice
	Chronic	X	X	NA	-	X	X	X	X	X	X	X	NA	NA	X

* An exceedance denoted in the table indicates an exceedance of a level of concern (LOC) for that crop. An italicized "X" means the RQ exceeds the listed species LOC. A dark shaded and bolded "X" represents an LOC exceedance of the listed species and non-listed species LOC's.

NA – Crop is not applicable/not assessed for the chemical. Not all assessed crops are included in the table, only the most commonly assessed crops across chemicals. As a result some chemicals have additional exceedances not shown here.

Benthic (sediment-dwelling) invertebrates tend to be more sensitive to the pyrethroids and pyrethrins than water column dwelling invertebrates, however benthic acute and chronic RQ's were generally lower than water column RQ's. For the most part all chemicals, for both pore water and sediment, had freshwater and estuarine/marine acute and chronic listed and non-listed exceedances of the LOC. The exceptions were cyfluthrin, which for acute pore water exposure for freshwater benthic organisms only exceeded the listed LOC, and the same was true for pyrethrins estuarine/marine benthic organisms. Deltamethrin, only had acute and chronic listed and nonlisted exceedances in pore water. Again, grapes/blueberries, cotton, and rice had the highest exceedances.

For most chemicals, there were no risks to aquatic plants. For vascular and non-vascular aquatic plants, there is no data available for bifenthrin or pyrethrins, and so no RQ's were calculated. There is no vascular plant data for permethrin or cyfluthrin. Pyrethrins exceeded the listed LOC for non-vascular plants for rice, and permethrin exceeded for all but alfalfa. Permethrin also exceeded for listed and non-listed vascular plants, and nonlisted non-vascular plants, for use on blueberries. Lambda-cyhalothrin exceeded listed and non-listed vascular plant LOC's for cotton and rice, and cypermethrin exceeded the listed and non-listed LOC on rice for vascular plants. No other listed or non-listed acute or chronic LOC's were exceeded for the remaining assessed active ingredients for vascular and non-vascular aquatic plants.

Pollinators

Finally, risks to pollinators was assessed for agricultural uses based on the Office of Pesticide Programs' (OPP's) published guidance entitled: *"Guidance for Assessing Pesticide Risks to Bees"* (USEPA 2014)². The uses with maximum application rates for crops that are attractive to bees were identified, based on the USDA 2015 guidance document: *Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen*³. For the assessed pyrethroids, this included tree nuts for bifenthrin,

² USEPA et al. 2014. Guidance for Assessing Pesticide Risks to Bees. <https://www.epa.gov/pollinator-protection/pollinator-risk-assessment-guidance>

³ USDA. 2015. *Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen*. http://www.ree.usda.gov/ree/news/Attractiveness_of_Agriculture_crops_to_pollinating_bees_Report-FINAL.pdf

deltamethrin, esfenvalerate, and permethrin; citrus for cyfluthrins, cyhalothrins, fenpropathrin, and pyrethrins, and cucurbits for cypermethrins.

Only acute and foliar residue contact studies have been required in the past, for some pyrethroids. The available data for bees include acute oral LD₅₀ values for adult bees that range about two orders of magnitude (0.012 µg a.i./bee for beta-cyfluthrin to 1.26 µg a.i./bee for gamma cyhalothrin). Acceptable acute oral LD₅₀ data were not submitted for bifenthrin, cyfluthrin, esfenvalerate, fenpropathrin, and pyrethrins. Acute contact LD₅₀ values for adult bees also range two orders of magnitude, from 0.0015 µg a.i./bee (deltamethrin) to 0.13 µg a.i./bee (beta cypermethrin). No acceptable acute contact study was submitted for fenpropathrin.

Given the high toxicity of pyrethroids to insects, and conservative exposure estimates in a Tier I screening level assessment, all acute RQ's exceeded the LOC of 0.4. Acute oral RQ's ranged from 2.7 (cyhalothrins) to 270 (cyfluthrins). Acute oral RQ's ranged from 6.1 (pyrethrins) to 59 (deltamethrin). The Pollinator Section of the Results of Previous Pyrethroid Risk Assessments in this document further discusses pollinator data needs and OPP's intention to further assess potential risks to pollinators.

Wide Area Mosquito Adulticide

Wide area adult mosquito control is unique compared to crop and non-crop uses, both in application method and in terms of benefits. While applications in conventional settings use ground or aerial applications of fine, medium or coarse droplets, mosquito adulticides are applied as extremely fine, Ultra-Low Volume (ULV) droplets using ground or aerial mists. Adulticide application rates are usually a very small fraction of the rate of coarser droplet applications in agriculture (*e.g.*, applied as ounces of product per acre). ULV droplets are intended to remain suspended in air to contact adult mosquitoes in flight. Wide area mosquito applications are made by government entities, to control mosquito-borne diseases, such as West Nile, Zika, dengue and other viruses affecting human health, and heartworm affecting pets. Of the PWG chemicals, deltamethrin, permethrin and pyrethrins have the wide-area mosquito adulticide use.

Like agricultural scenarios, mosquito adulticide uses are modeled using the Pesticide Water Calculator (PWC), in which exposure concentrations for surface waters assessments are estimated based on EFED's Tier II aquatic models, the Pesticide Root Zone Model (PRZM), and the Varying Volume Water Body Model (VVWM). EECs were determined using the standard pond scenario, which describes a vulnerable surface water scenario for the VVWM component of the modeling exercise. AGDRIFT is also used to calculate spray drift, specifically the deposition to a treated area and adjacent bodies of water. AGDISP allows for the parameters particular to ULV mosquito adulticide spraying to be modeled, including extremely fine droplet size, boom height spray volumes, wind speed and direction, spray material and specific gravity. The spray drift fraction and application efficiency are used in the PWC to calculate EEC's. Aerial applications for permethrin and pyrethrins, with no tree canopy on the ground, were assumed. Ground application for deltamethrin was modeled using deposition rates from open literature studies, since ground applications cannot currently be modeled in AGDISP. Aerial application for deltamethrin was also modeled based on a recent Experimental Use Permit granted by the Agency.

The freshwater and estuarine/marine fish acute LOC's were exceeded only for endangered species for pyrethrins and permethrin. Deltamethrin exceeded the listed and non-listed LOC (RQ up to 1.3, for aerial and up to 1.2 for ground) for freshwater fish, and the listed LOC only for estuarine/marine fish. The chronic listed and non-listed LOC was just exceeded for estuarine/marine fish for pyrethrins (RQ up to 1.1), and for estuarine/marine and freshwater fish for permethrin (RQ up to 3). There were no chronic exceedances for fish for deltamethrin.

For freshwater invertebrates, acute listed and non-listed LOC's were exceeded for deltamethrin (RQ's up to 1000 for aerial, 915 for ground), pyrethrins (RQ's up to 2.2), and permethrin (RQ's up to 53). For estuarine/marine invertebrates, acute listed and non-listed LOC's were also exceeded for deltamethrin (RQ's up to 54 for aerial, 49 for ground), pyrethrins (RQ's up to 1.2), and permethrin (RQ's up to 19).

Chronic listed and non-listed LOC's were also exceeded for all three chemicals for invertebrates. For freshwater invertebrates, deltamethrin RQ's were up to 400 for aerial application, and 198 for ground; for estuarine/marine invertebrates deltamethrin RQ's were up to 22 for aerial, and up to 11 for ground. Chronic freshwater invertebrate RQ's for pyrethrins ranged up to 34, and for estuarine/marine up to 5.4. For permethrin, chronic freshwater invertebrate RQ's ranged up to 40, and for estuarine/marine ranged up to 70. These generalized results are shown below in Table 14.

Table 14. Mosquito Adulticide Scenario Risk Quotients

Chemical	LOC Exceedances*							
	FW Fish		E/M Fish		FW Inverts**		E/M Inverts**	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Residential								
Deltamethrin	X	-	X	-	X	X	X	X
Permethrin	X	X	X	X	X	X	X	X
Pyrethrins	X	-	-	-	X	X	X	X
Turf								
Deltamethrin	X	-	-	-	X	X	X	X
Permethrin	X	X	X	-	X	X	X	X
Pyrethrins	X	-	X	X	X	X	X	X
Agriculture								
Deltamethrin	X	-	-	-	X	X	X	X
Permethrin	X	X	X	-	X	X	X	X
Pyrethrins	X	-	X	X	X	X	X	X

* An exceedance denoted in the table indicates that at least one of the residential, turf, and agricultural scenarios resulted in an exceedance of a level of concern (LOC). An italicized "X" means the RQ exceeds the listed species LOC. A dark shaded and bolded "**X**" represents an LOC exceedance of the listed species and non-listed species LOC's.

** Invertebrates in the water column.

Benthic (sediment-dwelling) invertebrates tend to be more sensitive to the pyrethroids and pyrethrins than water column dwelling invertebrates, however benthic acute and chronic RQ's were generally lower than water column RQ's. For freshwater benthic invertebrates, deltamethrin had listed and non-

listed acute and chronic LOC exceedances for pore water, and listed and non-listed chronic LOC exceedances for sediment. For estuarine/marine benthic invertebrates, deltamethrin had acute and chronic listed and non-listed exceedances only for pore water. Pyrethrins and permethrin had freshwater listed and non-listed acute and chronic exceedances for pore water, and listed and non-listed chronic LOC exceedances for sediment, although permethrin had exceedances for a greater number of scenarios. For estuarine/marine benthic invertebrates, pyrethrins had exceedances for pore water, acute listed and chronic listed and non-listed LOC's. Permethrin had pore water and sediment chronic listed and non-listed exceedances, and acute pore water listed and non-listed LOC exceedances.

There was no risk to aquatic plants for deltamethrin and permethrin. Risks to plants for pyrethrins could not be calculated due to lack of aquatic plant data.

For a full description of the models, inputs, assumptions, and results, see the EFED assessment titled "Preliminary Comparative Environmental Fate & Ecological Risk Assessment for the Registration Review of Eight Synthetic Pyrethroids and Pyrethrins, Part IV. Assessing the Mosquito Adulticide Uses of Pyrethroids and Pyrethrins" dated July 29, 2016.

Results of Previous Pyrethroid Risk Assessments

Aquatic Taxa Risk

The Agency's prior risk assessments indicate that the primary risk concern for pyrethroids is acute and chronic risk to aquatic organisms. These assessments have shown that pyrethroids and the pyrethrins are very highly toxic to aquatic organisms on an acute basis, based upon data for freshwater, estuarine, and marine species of aquatic vertebrates and invertebrates. Chronic effects are also seen in aquatic taxa. While the pyrethroids do show a spectrum of toxicity to aquatic animals, the LC₅₀ values are in the parts per billion (ppb) and parts per trillion (ppt) range.

Agency Levels of Concern (LOC) for aquatic animals are in Table 15 below:

Table 15. Agency Levels of Concern (LOC) for Aquatic Animals

Risk Presumption	RQ	LOC
Acute Risk	EEC/LC ₅₀ or EC ₅₀	0.5
Acute Endangered Species	EEC/LC ₅₀ or EC ₅₀	0.05
Chronic Risk	EEC/NOAEC	1.0

The updated RQ's in the current assessment are consistent with what has been found in previous risk assessments for the nine PWG chemicals. Also, even though not all of the pyrethroids were quantitatively assessed in the current assessment, results from previous assessments of the other chemicals are consistent with the results seen in the current assessment for the nine PWG chemicals. Quantitatively assessing the non-PWG chemicals again would give similar results to previous assessments, just as it has for the nine PWG chemicals.

RQ's for water column aquatic organisms described in previous risk assessments are presented in the figures below. The bibliography of the source assessments for these RQ's can be found in **Appendix A**. The RQ's are also presented in table format for each chemical, citing the source assessments, in **Appendix B**.

The figures 1-8 below include:

- RQ's for the newly assessed PWG chemicals (bifenthrin, cypermethrins, cyfluthrins, deltamethrin, esfenvalerate, fenpropathrin, cyhalothrins, permethrin, and the pyrethrins) from previous assessments cited in the registration review problem formulations, where available.
- For chemicals not included in the current assessment, both RQ's from assessments cited in the problem formulations, and RQ's from new use assessments completed since the problem formulations (where available).

The figures 1-8 below do **not** include:

- RQ's from the current assessment for the newly assessed active ingredients. The updated RQ's from the 2016 current assessment are described in the previous section entitled *Results of the Streamlined Ecological Assessment on the Nine PWG Chemicals*.
- RQ's for the newly assessed PWG chemicals from new use assessments completed since the problem formulations.

- RQ's for Bifenthrin, cyfluthrins, deltamethrin, esfenvalerate, and permethrin from Endangered Species Act (ESA) assessment. However, RQ's from these assessments are included in the tables in Appendix A and are discussed in the individual chemical descriptions that follow the figures below.
- RQ's for cyphenothrin, flumethrin, imiprothrin, momfluothrin, and tetramethrin, which have not been previously calculated due to lack of exposure.

Figure 1 below shows the ranges of acute RQ's for each chemical for freshwater fish. Bifenthrin, cyfluthrins, cyhalothrins, cypermethrin and zeta-cypermethrin, esfenvalerate, fenpropathrin, permethrin, pyrethrins, tau-fluvalinate, and tefluthrin exceeded the listed and non-listed LOC's. Alpha-cypermethrin, deltamethrin, etofenprox, and prallethrin exceeded the listed LOC only. D-phenothrin did not exceed either LOC.

Figure 1.

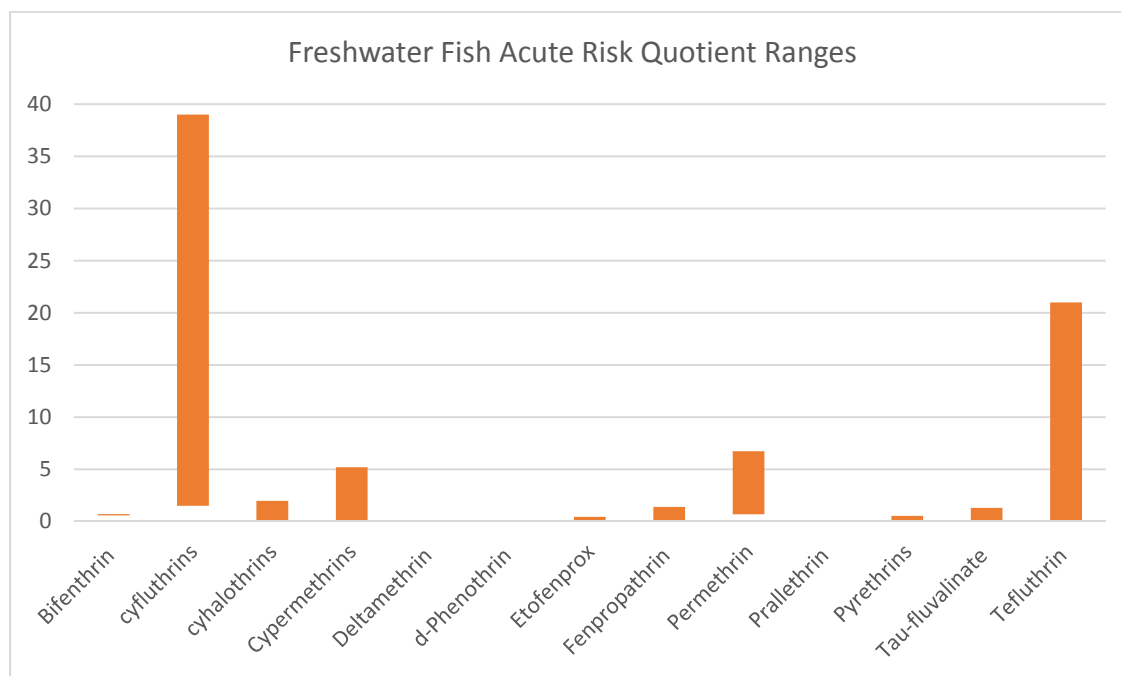
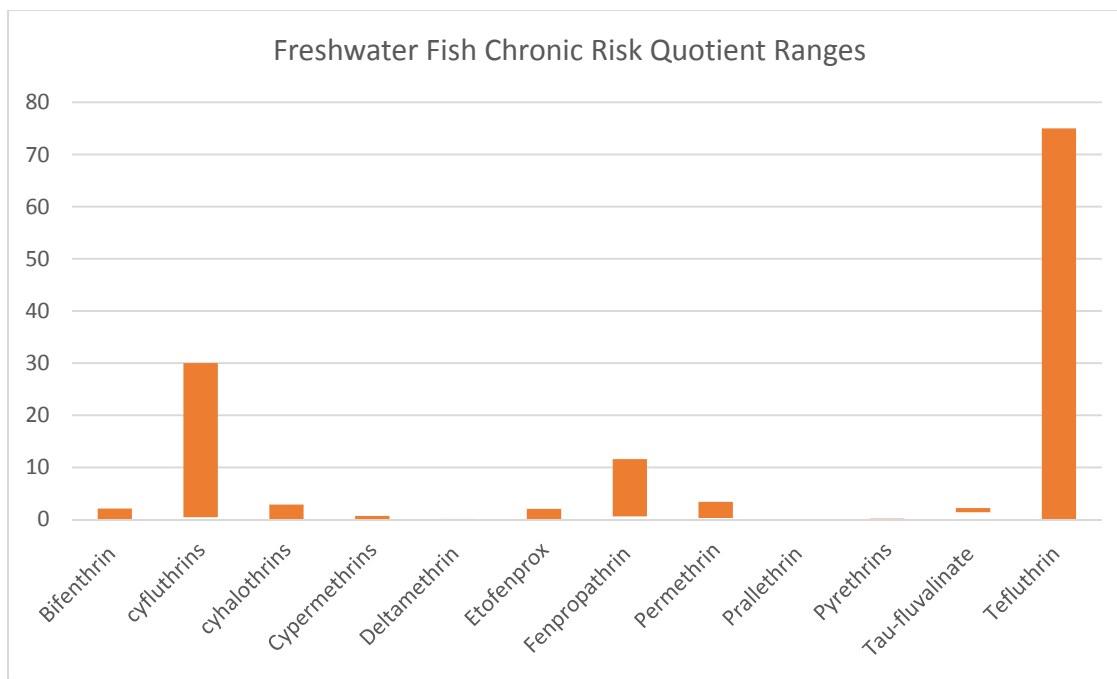


Figure 2 shows the ranges of chronic RQ's for freshwater fish. All of the chemicals for which RQ's were calculated exceed the listed and non-listed LOC, except for the cypermethrins, prallethrin, and pyrethrins.

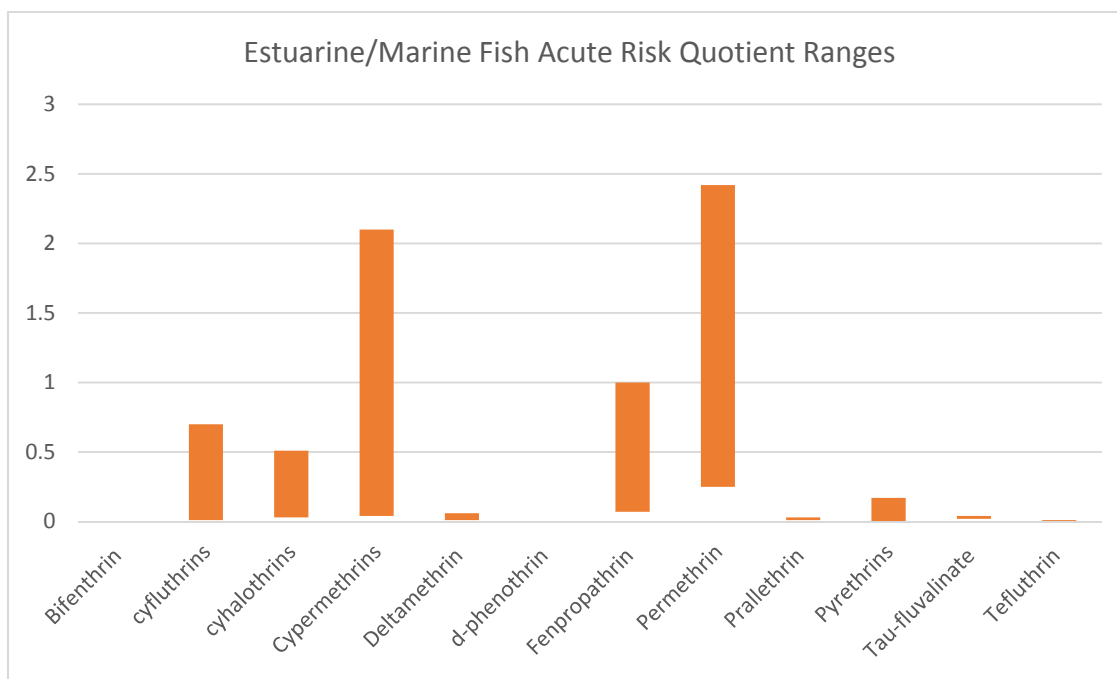
Figure 2.



RQ's were not calculated for d-phenothrin in previous assessments.

The relatively lower acute RQ ranges are shown for estuarine/marine fish in Figure 3. Cyfluthrins, cyhalothrins, cypermethrins, fenpropathrin, and permethrin all exceeded the listed and non-listed LOC's. Deltamethrin and pyrethrins exceeded the listed LOC. D-phenothrin, prallethrin, and tau-fluvalinate had no exceedances.

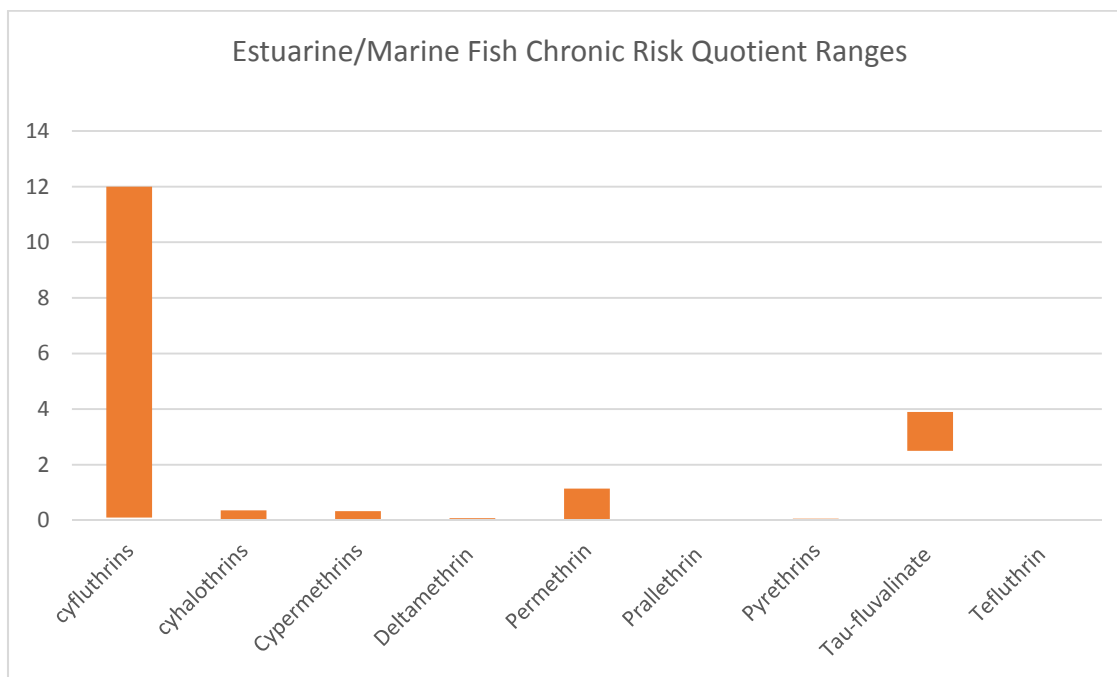
Figure 3.



RQ's were not calculated for etofenprox in previous assessments.

The estuarine/marine fish chronic RQ ranges in Figure 4 show listed and non-listed LOC exceedances for cyfluthrins, permethrin, and tau-fluvalinate. RQ's are again lower than those for freshwater fish. Cyhalothrins, cypermethrins, deltamethrin, prallethrin, pyrethrins, and tefluthrin did not exceed the LOC.

Figure 4.



RQ's were not calculated for bifenthrin, d-phenothrin, etofenprox, or fenpropathrin in previous assessments.

Freshwater invertebrate acute risk quotient ranges in Figure 5 show much higher RQ's than for fish. Cyfluthrins, cyhalothrins, cypermethrins, deltamethrin, fenpropathrin, permethrin, prallethrin, and tau-fluvalinate exceeded the listed and non-listed LOC's. Bifenthrin, d-phenothrin, etofenprox, and pyrethrins exceed the listed LOC only. Tefluthrin did not exceed either LOC.

Figure 5.

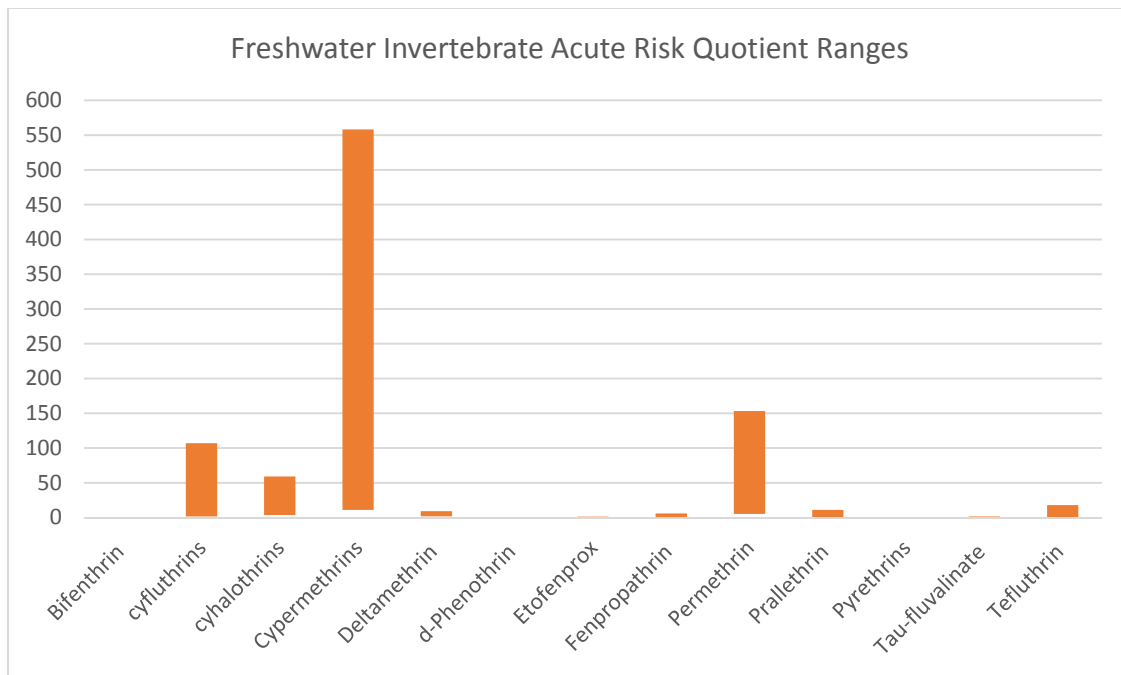
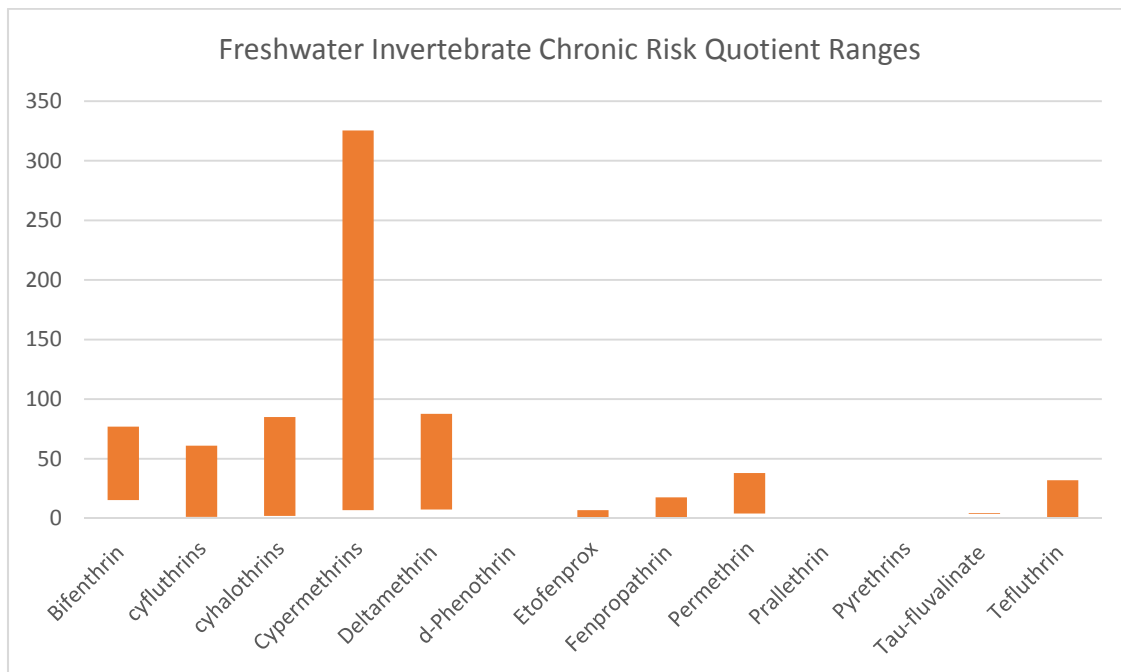


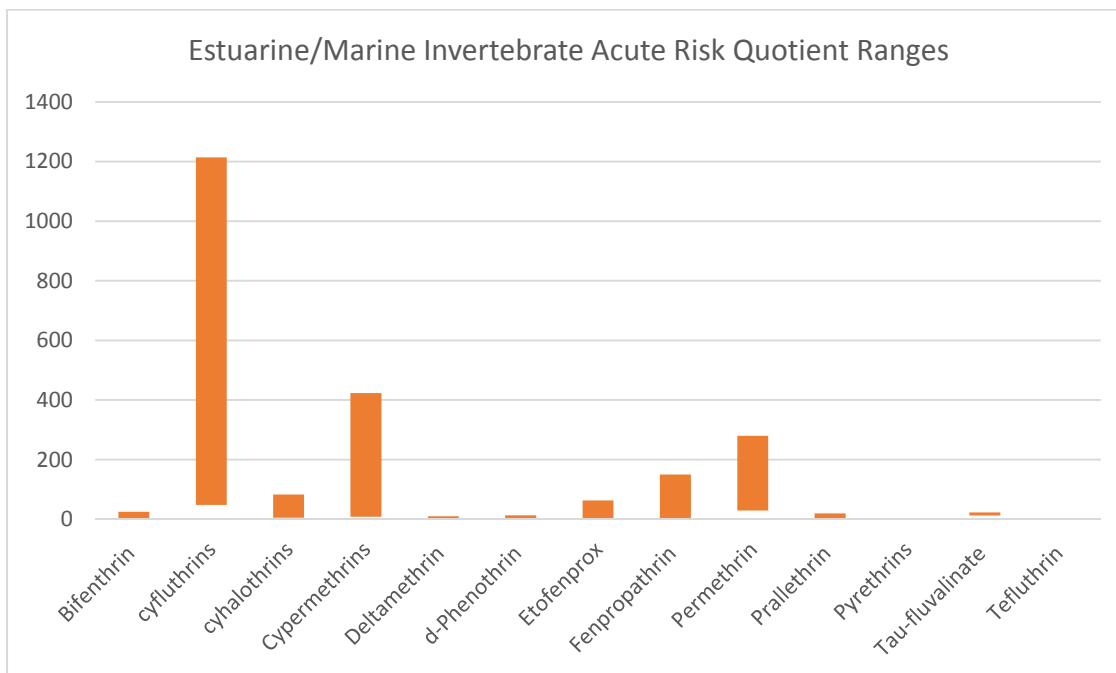
Figure 6 shows chronic risk quotient ranges for freshwater invertebrates. All chemicals except d-phenothrin, prallethrin, and pyrethrins exceeded the listed and non-listed LOC.

Figure 6.



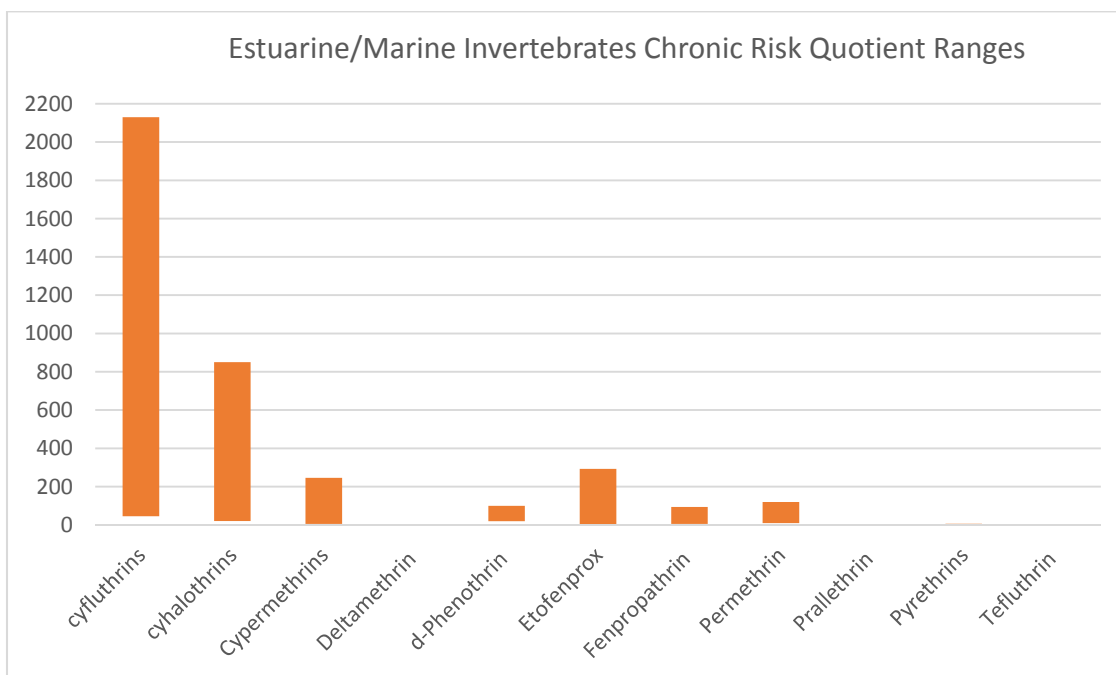
Estuarine/marine invertebrate acute RQ's (Figure 7) exceeded the listed and non-listed LOC's for all chemicals.

Figure 7.



Estuarine/marine invertebrate chronic RQ's (Figure 8) exceeded the listed and non-listed LOC's for all chemicals except tau-fluvalinate.

Figure 8.



RQ's were not calculated for bifenthrin or tau-fluvalinate in previous assessments.

A brief description of the results of previous assessments is presented below for each chemical, focusing on LOC exceedances for aquatic taxa in the water column. The bibliography of the source assessments can be found in **Appendix A**. The RQ's discussed below are also presented in table format for each chemical, citing the source assessments, in **Appendix B**.

Bifenthrin was assessed for several new uses in 2007 and as part of an endangered species assessment for a number of species in 2012. Acute RQ's for freshwater fish exceeded the listed LOC and just met or exceeded the non-listed LOC in the 2007 assessment. Estuarine/marine fish RQ's were not calculated in this assessment. In the 2012 ESA assessment, freshwater fish acute RQ's exceeded only the listed LOC. For chronic risk to freshwater fish, RQ's exceeded listed and non-listed LOC's in both assessments. Estuarine and marine fish acute RQ's were below 0.01 in the ESA assessment, while chronic estuarine and marine fish RQ's exceeded the listed and non-listed LOC's. Freshwater and estuarine/marine invertebrate RQ's both exceeded acute and chronic listed and non-listed LOC's in the ESA assessment. The same was true of the 2007 assessment, with the exception of acute freshwater, which only exceeded the listed LOC, and estuarine/marine chronic, which were not calculated.

Data for the registration review of bifenthrin and reviewed by the Agency were consistent with the previous understanding of the chemical's toxicity. A full life-cycle chronic study with the estuarine/marine fish sheepshead minnow resulted in a NOAEC of 0.1 µg/L, based on time to hatch and reproductive success (MRID 49412101). Acute toxicity study for the benthic invertebrate *Hyaella azteca* resulted in an LC₅₀ of 0.493 ng ai/L (MRID 49552201), and a 10-day acute whole sediment studies resulted in an LC₅₀ of 276 ng ai/kg (MRID 49462202), 41 µg /kg (MRID 49368101), and 3.7 µg ai/kg (MRID 48593601), respectively. These studies indicate that bifenthrin is very highly toxic to this invertebrate.

Bifenthrin was newly assessed in the 2016 streamlined assessment; see the current assessment for a full discussion of results.

Cyfluthrin was assessed in 2004 for multiple new uses, and again in 2013 as part of an ESA endangered species assessment for a number of species. Acute and chronic risks to freshwater fish exceeded the listed and non-listed LOC's. Acute risks to estuarine and marine fish were low, with RQ's exceeding the listed LOC and just exceeding the non-listed LOC, while chronic RQ's exceeded the listed and non-listed LOC's. Freshwater and marine invertebrate acute and chronic RQ's exceeded both the listed and non-listed LOC's, and were high as expected, ranging up to 766 for freshwater chronic and up to 32,857 for estuarine /marine chronic in the ESA assessment.

New data submitted for the registration review of cyfluthrin and reviewed by the Agency includes a mysid chronic toxicity test, where the NOAEC was 0.41 ng a.i./L (MRID 49272611). For benthic invertebrates, an acute 10 day *Hyaella* test found an LC₅₀ of 4.8 µg ai/kg (MRID 48593606) and 116 µg ai/kg (MRID 49209503), and a 42 day chronic sediment test resulted in a NOAEC of 8 µg ai/kg (MRID 49272613). An acute study with *Chironomus dilutus* found an LC₅₀ of 88 µg ai/kg (MRID 48593607), and a life cycle study found a NOAEC of 1.6 µg ai/kg (MRID 49272612).

Beta-cyfluthrin is an enriched isomer mixture of cyfluthrin, and new use assessments since the problem formulation have relied on previous cyfluthrin assessments. According to the 2010 registration review problem formulation, "(b)eta-cyfluthrin consists of four of the eight possible isomers of cyfluthrin, which are the more potent isomers of cyfluthrin. Thus, its application rate is usually lower than that for cyfluthrin. The environmental fate and ecological effects properties of cyfluthrin and beta-cyfluthrin are

expected to be similar to each other. Although beta-cyfluthrin registrations are separate from cyfluthrin, the environmental fate and ecological database for beta-cyfluthrin has been largely supplemented by available data for cyfluthrin.”

The cyfluthrins were newly assessed in the 2016 streamlined assessment; see the current assessment for a full discussion of results.

Cyhalothrins were assessed in 2002 for several new uses. Acute RQ’s for freshwater fish exceeded the listed LOC, and met and just exceeded the non-listed LOC. The chronic RQ exceeded the listed LOC. For estuarine/marine fish, there were acute listed exceedances. Freshwater and estuarine/marine invertebrate RQ’s exceeded the acute and chronic listed and non-listed LOC’s.

Cyhalothrins were also assessed in 2006 for several new uses. Acute and chronic risks for freshwater fish exceeded the listed and non-listed LOC’s. Acute RQ’s for estuarine/marine fish exceeded the non-listed LOC and barely reached the nonlisted LOC. There were no chronic exceedances. Freshwater and estuarine/marine invertebrate RQ’s exceeded acute and chronic listed and non-listed LOC’s. Cyhalothrins have not been assessed since the 2010 problem formulation for registration review.

An acute hyalella study with gamma-cyhalothrin submitted for registration review and reviewed by the Agency found an LC₅₀ of 0.0823 ng ai/L (MRID 49463701), which is consistent with previously submitted data.

Cypermethrin (racemic) was assessed in the 2005 RED, and the EFED chapter was later revised in 2006 and included in the final 2008 RED. Alpha-cypermethrin was assessed as a new active ingredient when it was first registered in 2012. Zeta-cypermethrin was assessed in 2006 for multiple new crop uses, turf and ornamentals, and a termiticide use.

For racemic cypermethrin, the revised RED updated risk estimates, and acute freshwater and estuarine/marine fish RQ’s exceeded listed and non-listed LOC’s. Chronic RQ’s did not exceed the LOC for fish. As expected, freshwater and estuarine/marine invertebrate RQ’s exceeded acute and chronic listed and non-listed LOC’s.

Alpha-cypermethrin did not have acute or chronic LOC exceedances for freshwater fish. For estuarine/marine fish, acute RQ’s exceeded the listed LOC and just barely exceeded the non-listed LOC, with no chronic exceedances. The acute and chronic listed and non-listed LOC’s were exceeded for freshwater and estuarine/marine invertebrates. Zeta-cypermethrin had acute listed and non-listed exceedances for multiple new uses for freshwater and estuarine/marine fish, with no chronic fish exceedances. The acute and chronic listed and non-listed LOC’s were exceeded for freshwater and estuarine/marine invertebrates.

A freshwater fish study on cypermethrin submitted for registration review and reviewed by the Agency found an LD₅₀ of 0.468 µg /L (MRID 49642301). A freshwater invertebrate study on *Hyalella* found an LC₅₀ of 0.56 ng a.i./L (MRID 49274301), again consistent with the previous understanding of the toxicity of cypermethrin.

The cypermethrins were newly assessed in the 2016 streamlined assessment, see current assessment for a full discussion of results.

Cyphenothrin has not been assessed (RQ's not calculated), according to the 2009 problem formulation, for risks to aquatic taxa because there are no registered outdoor uses. The one structural aerosol spray use was registered in 2009 and canceled in 2016. Cyphenothrin only has indoor use sites, including household/domestic dwellings, storage areas, dogs and horse spot-ons, pet living/sleeping quarters, ships and boats, and processing plants. Cyphenothrin labels do not include indoor uses that, according to the Agency's conceptual model, would result in direct exposure down the drain to sanitary sewers and WWTP's/POTWs. A new use assessment was completed in 2013 for a pet product that was determined to be similar a spot-on treatment, rather than a shampoo, and so there does not appear to be a complete exposure pathway for aquatic organisms from this use. It is possible that dogs treated with the squeeze-on spot treatment could at times be washed indoors, but this is unlikely to occur soon after treatment. Hand-washing following application or subsequent contact with the pet could also potentially lead to residues entering indoor drains, but this is difficult to quantify and realistically assess.

Deltamethrin was assessed in 2013 as part of an ESA endangered species assessment and in 2014 for use as a mosquito adulticide. Prior to that, new use assessments relied on the last comprehensive assessment completed in 1994. In the adulticide assessment, acute and chronic RQ's for fish were low and did not exceed the non-listed LOC, however, RQ's did just exceed the acute LOC for endangered species. Acute and chronic RQ's for freshwater and estuarine/marine invertebrates exceeded the listed and non-listed LOC's. Chronic RQ's for freshwater invertebrates were uncertain, indicating that RQ's could be higher, because the freshwater invertebrate chronic endpoint was non-definitive, at 10-d NOAEC of <0.026 ng a.i./L.

The 2013 ESA assessment found acute listed and chronic listed and non-listed LOC exceedances for freshwater and estuarine/marine fish. Freshwater and estuarine/marine invertebrate acute listed and non-listed LOC's were exceeded with RQ's in the 50's for both, while the chronic freshwater and estuarine/marine LOC was exceeded with RQ's up to >7690 and 274, respectively.

The results of newly submitted toxicity studies are consistent with our previous understanding of overall pyrethroid toxicity. Chronic toxicity to estuarine/marine invertebrates at low concentrations was observed in the life-cycle toxicity test with mysid shrimp, with a NOAEC of 0.47 ng ai/L based on adult survival (MRID 48988202). Chronic toxicity to estuarine/marine fish at low concentrations was also observed in the sheepshead minnow early life-stage study, with a NOAEC of 0.024 µg ai/L based on slight but significant treatment-related decreases in growth (48988203).

Deltamethrin was newly assessed in the 2016 streamlined assessment, see previous section for discussion of results.

The 2008 **d-Phenothrin** RED assessed risk from the mosquito abatement use only, and not for indoor residential (down the drain) uses⁴. Risk to fish was not assessed in the 2008 RED because acute and chronic data were not available for freshwater and marine fish. However, peak aquatic EECs in the 2008 RED ranged from 0.08 to 0.325 ppb. Freshwater fish (bluegill) acute and chronic endpoints were later established at 15.8 and 1.1 ppb, respectively. Comparison of the EECs to the toxicity values indicates that d-phenothrin would not have been found to be a risk to freshwater fish.

⁴ See Appendix C for additional information on the down the drain uses.

The freshwater invertebrate acute RQ's in the 2008 RED exceeded the listed LOC only, and the chronic freshwater invertebrate RQ's exceeded the listed LOC and just barely exceeded the non-listed LOC. In contrast, the estuarine/marine invertebrate acute and chronic RQ's all exceed the non-listed LOC. These RQ's were based on an endpoint of 0.0026 ppb, estimated by calculating an acute-to-chronic ratio with existing data. A later data submission established the estuarine/marine invertebrate chronic endpoint at 0.022 ppb. While this indicates that the estimated RQ's were too high by an order-of-magnitude, revised RQ's would still exceed the chronic LOC.

D-phenothrin was most recently assessed in 2012 on outdoor residential misting systems. Since spray drift was expected to drive the risk, only acute RQ's were calculated, based on single daily EEC's. The freshwater and estuarine/marine fish RQ's were well below endangered and non-endangered LOC's. The freshwater invertebrate RQ was also below the LOC's, and the estuarine/marine RQ exceeded the LOC at 1.20.

D-phenothrin was reviewed in 2013 for a new use as a mosquito adulticide product co-formulated with piperonyl butoxide. Since d-phenothrin was already registered as a mosquito adulticide and assessed in the RED, and the same rate was proposed, this assessment relied on the conclusions of the 2008 RED. In summary, previous risk assessments indicate from available data that d-phenothrin poses a risk to estuarine/marine invertebrates but not to freshwater fish or invertebrates.

Esfenvalerate was assessed in 2003, but RQ's were not calculated for any taxa, since this assessment relied on prior assessments from the 1990's that did not include RQ's. However esfenvalerate was also part of the 2008 ESA endangered species California red legged frog assessment. RQ's for freshwater fish exceeded the acute and chronic listed and non-listed LOC's. RQ's for freshwater invertebrates were based on the fenvalerate 48-hour LC₅₀ of 0.05 ppb. Acute RQ's went up to 77.24 for agricultural uses and up to 129.6 for non-agricultural impervious surfaces, exceeding listed and non-listed LOC's. Chronic RQ's also exceeded the LOC for agricultural and non-agricultural impervious surfaces.

The results of newly submitted toxicity studies for registration review were consistent with the previous understanding that esfenvalerate causes adverse toxic effects to aquatic invertebrates at very low concentrations. A chronic estuarine/marine toxicity study with mysid shrimp resulted in a NOAEC of 0.17 ng ai/L, based on the number of offspring/female and time to first brood (MRID 49140707). A mysid acute toxicity test found an LC₅₀ of 3.39 ng ai/L (MRID 49140406). An acute toxicity test with the benthic aquatic invertebrate *Hyalella azteca* resulted in an LC₅₀ of 0.848 ng ai/L at 96 hours (MRID 49209501). A study on another benthic invertebrate, *Chironomus dilutes*, found a NOAEC of 2 µg ai/kg with the most sensitive endpoint being day-20 survival (MRID 49082601). An acute study with sheepshead minnow did not establish an endpoint, but there was no mortality at the highest concentration tested, which was near the solubility limit (LC₅₀ >6 µg ai/L) (MIRD 48831603), and a chronic test found a NOAEC of 0.63 µg ai/L with the most sensitive endpoint being hatching success and length at 19 weeks (MRID 4928902).

Esfenvalerate was newly assessed in the 2016 streamlined assessment, see previous section for discussion of results.

Etofenprox was assessed in 2008 for section 3 new uses on both a granular application to rice paddies and an ultra-low volume aerial spray as a mosquito adulticide. The freshwater fish RQ's for the rice use exceeded the listed but not the non-listed acute LOC, and exceeded the listed and non-listed chronic LOC. For the adulticide use, only the acute listed LOC was exceeded. The chronic RQ's were based on an

estimated tox endpoint of 0.57 ppb, calculated using an acute-to-chronic ratio from invertebrate data. A subsequently submitted chronic freshwater fish study established a NOAEC of 0.67 ppb; the new endpoint would not change the conclusions for chronic risk to freshwater fish. No acute risk was indicated for estuarine marine fish, as etofenprox was seen to not be toxic at the level of solubility. No chronic data are available for estuarine/marine fish, which were not assessed for this reason. However, etofenprox was determined to pose a risk to freshwater and estuarine/marine aquatic invertebrates for both the rice and vector control use. The acute and chronic RQ's were significantly higher for estuarine/marine invertebrates compared to freshwater, exceeding the listed and non-listed LOC's. Mosquito adulticide acute RQ's were 0.5 (freshwater) and 21.3 (estuarine/marine), and chronic RQ's were 1.59 (freshwater) and 68 (estuarine/marine). The rice use had higher RQ's than for vector control.

A 2010 new use assessment on ant mounds found RQ's for freshwater fish and invertebrates below the listed and non-listed LOC's. RQ's were not calculated for estuarine/marine fish because no data were available. Acute and chronic RQ's exceeded the LOC for listed and non-listed species for estuarine/marine invertebrates, both at 1.8.

The 2007 problem formulation for etofenprox addressed previously registered indoor and outdoor residential uses. The document states that, "(a)lthough there are a number of specified uses of etofenprox for use as an indoor crack and crevice insecticide, exposures to non-target wildlife and plants are not expected to occur as a result of these uses." The other indoor use described was a spot treatment for cats. This use is not included in the Agency's conceptual model as one that would result in direct exposure down the drain to sanitary sewers and POTWs.

The problem formulation included a screening assessment of the potential risk to fish and invertebrates from outdoor yard and patio fogger treatment. This assessment assumed that the contents of an entire fogger can were to be deposited in the standard pond used for ecological risk assessment. The resulting acute RQ's for freshwater fish and invertebrates were 0.04 and 0.19, respectively, indicating no acute risk to non-listed aquatic animals. No chronic risk is expected from this type of use, and RQ's were not calculated.

The results of newly submitted toxicity studies for registration review were consistent with the previous understanding that etofenprox causes adverse toxic effects to aquatic invertebrates at very low concentrations. A freshwater fish early life-stage study resulted in a NOAEC of 670 ng/L based on time to swim-up and post-hatch survival (48280205). Chronic freshwater (daphnia) and estuarine/marine (mysid) toxicity studies resulted in NOAEC values of 103 and 3.7 ng/L (MRID 48280204), respectively, based on reproductive and other effects. More recently submitted toxicity data for *hyalella azteca* indicate that this benthic invertebrate is more sensitive than *Daphnia magna*, and could also be expected to be at risk from exposure to etofenprox. An acute *Daphnia* study found an EC50 of 18.1 µg ai/L (MRID 48280201).

Fenpropathrin was assessed in 2008 for multiple new uses, and had LOC exceedances for listed and non-listed freshwater fish acute and chronic LOC's. Freshwater invertebrate RQ's also exceeded the listed and non-listed acute and chronic LOC's. Estuarine/marine fish RQ's just exceeded the acute risk listed and non-listed LOC's (0.07-1.0), while chronic risk was not calculated due to lack of data. Estuarine/marine invertebrate chronic RQ's exceeded the listed and non-listed LOC's.

Recently submitted data for the registration review of fenpropathrin is consistent with previously submitted studies for aquatic organisms. Data reviewed by the Agency included a chronic sheepshead minnow study that found a NOAEC of 0.81 µg ai/L (MRID 48536801). An acute *Hyalella* study found an LC₅₀ of 3.05 ng ai/L (MRID 49209502), while an acute *Daphnia* study found an EC₅₀ of 0.0273 mg ai/L (MRID 49604601), indicating that *Hyalella* is likely more sensitive. In contrast, a study on a metabolite of fenpropathrin, TMPA, found an EC₅₀ of >72 mg ai/L (MRID 49604602).

Fenpropathrin was newly assessed in the 2016 streamlined assessment, see previous section for discussion of results.

The 2016 **flumethrin** assessment, 'Preliminary Problem Formulation and Ecological Risk Assessment and Effects Determination in Support of Registration Review,' states, "(g)iven the exclusive use of flumethrin in pet collars and that these collars are typically applied to domesticated animals that spend a large proportion of their time indoors, the use of flumethrin is considered to be primarily a use with *de minimus* exposure for non-target organisms." RQ's have not been calculated for flumethrin because the use in pet collars is not expected to lead to direct outdoor exposure, or through transport down the drain.

A limited number of outdoor residential uses for **imiprothrin** were registered in 2006. Before that time, use sites only included indoor crack and crevice sprays. These uses are not included in the Agency's conceptual model as one that would result in direct exposure down the drain to sanitary sewers and POTWs. The 2006 ecological risk assessment of proposed outdoor uses as a treatment to cracks, crevices, and building perimeters/exterior did not calculate RQ's. However, the risk assessment concluded that the proposed aerosol can and directed spray formulations "were not expected to result in substantial environmental exposure to non-target aquatic or terrestrial organisms." (See Table 1a and 1b of uses for each a.i.). The 2011 problem formulation indicated the need for additional data for birds and terrestrial plants, but expressed the difficulty of estimating exposure from the current outdoor uses, stating that "(a)lthough there are uncertainties regarding the extent of use in residential settings, the cumulative exposure from these treatments is not likely to be substantial given that small amounts are used outdoors at one time, outdoor uses are limited to spot treatments, and methods of application (i.e., spray cans and trigger sprayers) are not feasible for treating large spatial areas."

Available data for aquatic organisms indicate that imiprothrin is less acutely toxic than many other pyrethroids, with an acute freshwater fish LD₅₀ of 38 ppb (rainbow trout, MRID 43750716), and an acute freshwater invertebrate LD₅₀ of 51 ppb (*Daphnia magna*, MRID 43750717). Some pyrethroids with a greater potential for aquatic exposure have acute toxicity endpoints of less than 1 ppb. Newly submitted data for registration review for mysids and reviewed by the Agency found an LC₅₀ of 5.938 µg ai/L (49625301), classifying imiprothrin as very highly toxic.

RQ's have not been calculated for **momfluorothrin** because there are limited outdoor uses, only aerosol sprays for residential crack and crevice and wasp and hornet nest treatments, see Tables 1a-1b of uses for each active ingredient. The 2014 registration assessment concluded that aquatic exposure to reach the LOC was unlikely, especially because direct application to water is prohibited, and applications near surface water have a 25 foot buffer on labels. Momfluorothrin is very highly toxic to freshwater fish (LC₅₀ = 1.2 µg a.i./L) on an acute basis, but no effects were seen on a chronic basis to freshwater fish. Similarly, it is very highly toxic to freshwater invertebrates (EC₅₀ = 7.8 µg a.i./L) but no effects were seen in the chronic study. No data are available for estuarine/marine fish or invertebrates.

Although significant aquatic exposure to momfluothrin is not expected, newly submitted studies for registration review further indicate that momfluothrin would cause adverse toxic effects to aquatic animals if exposure were to occur. Although the studies have not yet formally been reviewed, acute freshwater fish toxicity studies with rainbow trout and bluegill sunfish appear to have resulted in LD₅₀ values of 1.2 and 2.9 µg ai/L, respectively. Similarly, acute and chronic freshwater invertebrate (daphnia) studies indicate high toxicity at low concentrations, with an EC₅₀ value of 7.6 µg ai/L and a chronic NOAEC of 0.5 µg ai/L, based on dry weight.

Permethrin was last assessed in the 2009 RED, which incorporated a revised EFED RED chapter from 2006. A 2008 ESA endangered species assessment for the California red legged frog has also been completed. Acute and chronic RQ's for freshwater and estuarine/marine fish exceeded the listed and non-listed LOC's. For freshwater invertebrates, there were larger non-listed LOC exceedances than for fish. Specifically for the adulticide use assessed in the RED, RQ's were lower but there were listed species acute exceedances for fish, and listed and non-listed acute and chronic exceedances for invertebrates, the highest RQ's being for estuarine/marine (acute 15.68, chronic 16.91). LOC exceedances were still greater for estuarine/marine invertebrates, ranging up to 306 for acute exposure and up to 3817 for chronic exposure in the ESA assessment.

The results of newly submitted toxicity studies for registration review were consistent with the previous understanding that permethrin causes adverse toxic effects to aquatic invertebrates at very low concentrations. A full life-cycle estuarine/marine toxicity test done with mysid shrimp resulted in a NOAEC of 2.4 ng/L, based on offspring per surviving reproductive female (MRID 49554601). An acute freshwater invertebrate test with *Hyalella Azteca* resulted in an LD₅₀ of 6.59 ng/L (MRID 49513901).

Permethrin was newly assessed in the 2016 streamlined assessment, see previous section for discussion of results.

Prallethrin was assessed as a new use as a mosquito adulticide in, near and around agricultural fields in 2014. These uses had been assessed previously in 2003 and 2005, but following comments from the registrants regarding spray drift deposition rates and/or longer application intervals to revise EEC's, these assessments were revised in the 2014 assessment. For freshwater fish inhabiting shallow bodies of water (rice paddies) acute exposure RQ's ranged from <0.01 to 0.06, just exceeding the listed LOC. Chronic freshwater fish RQ's were below the listed LOC for agricultural uses, but were not calculated for the rice use/shallow water bodies because there were no exceedances in the Tier I rice model. There were no estuarine/marine fish acute or chronic exceedances. Freshwater invertebrate acute exposure RQ's exceeded the listed and non-listed LOC's, with no chronic exceedances for agricultural uses. Chronic RQ's were not calculated for rice paddies/shallow water bodies because again there were no exceedances in the Tier I rice model. Estuarine/marine invertebrate acute and chronic RQ's exceeded the listed and non-listed LOC's for shallow bodies of water only.

The results of newly submitted toxicity studies for registration review were consistent with the previous understanding that prallethrin causes adverse toxic effects to fish and aquatic invertebrates at very low concentrations. A freshwater fish acute toxicity study with rainbow trout exposed to prallethrin with the synergist PBO resulted in an LC₅₀ of 4.9 µg a.i./L (MRID 49430801). An acute toxicity study with the benthic freshwater invertebrate *Hyalella azteca* resulted in an LC₅₀ of 6.16 µg a.i./L (49450701). A similar study including the synergist PBO resulted in an LC₅₀ of 0.962 µg a.i./L (MRID 49452601).

The **pyrethrins** were assessed in the 2006 RED. For agricultural uses, freshwater fish acute RQ's were low and exceeded the listed LOC but barely exceeded the non-listed LOC, with chronic RQ's exceeding only the listed LOC. RQ's for estuarine/marine fish were similarly low, exceeding only the listed LOC for acute and chronic exposure. Freshwater invertebrate acute RQ's exceeded only the listed LOC, with chronic just exceeding the non-listed. Estuarine/marine invertebrate acute and chronic RQ's did exceed the listed and non-listed LOC's. For the mosquito adulticide wide area uses, there were no exceedances except for estuarine/marine invertebrates of listed and nonlisted LOC's (acute RQ's 0.02-0.95). A down the drain assessment was also done in the RED for pyrethrins, with acute RQ's all <0.00, with the exception again of estuarine/marine invertebrates, which were still below the listed LOC.

The results of newly submitted toxicity studies for registration review were consistent with the previous understanding that pyrethrins cause adverse toxic effects to aquatic invertebrates at very low concentrations. An early life-cycle toxicity test with sheepshead minnow resulted in a NOAEC of 0.7 µg ai/L, based on effects to dry weight (48931401). An acute freshwater invertebrate test with *Hyaella azteca* with the "pyrethrum stewardship blend" formulation resulted in a 96-hr LC₅₀ value of 0.76 µg ai/L (MRID 49066401). A chronic estuarine/marine invertebrate (mysid) with the same formulation resulted in a NOAEC of 0.12 µg total pyrethrins/L (MRID 49233202).

The pyrethrins were newly assessed in the 2016 streamlined assessment, see previous section for discussion of results.

Previous risk assessments for **tau-fluvalinate** indicated a potential risk to fish, although the risk quotients were not high. In the RED, the RQ's for freshwater fish were 0.7 for ornamentals and 1.3 for California carrots. The RQ's for both fish taxa were below the listed and non-listed LOC's for estuarine/marine fish. Chronic RQ's for freshwater and estuarine/marine fish exceeded the listed and non-listed LOC's. An acute study on the estuarine/marine fish sheepshead minnow submitted for registration review and reviewed by the Agency found a 96 hour LC₅₀ of 1.7 µg ai/L, which would classify tau-fluvalinate as very highly toxic to juvenile sheepshead minnow (MRID 47338004).

Acute risk quotients for freshwater and estuarine/marine invertebrates also exceeded LOC's. Chronic RQ's for freshwater estuarine/marine invertebrates also exceeded the LOC. The acute RQ's for estuarine/marine invertebrates were significantly higher than those for freshwater.

Tefluthrin was registered for use on corn in 1989, and the 1987 ecological risk assessment for this granular formulation compared estimated exposure to the toxicity endpoints still in use today, which indicated a potential acute risk to freshwater fish (RQ = 0.55), estuarine/marine invertebrates (RQ = 0.62) and a chronic risk to freshwater invertebrates (RQ = 3.8). The 2010 new use assessment for use on beet seeds concluded that this use of tefluthrin "does not pose acute or chronic risk to non-endangered, endangered, and listed species of aquatic organisms including freshwater fish and invertebrates." The low RQ's for tefluthrin reflected very low exposure due to a combination of soil incorporation and a propensity to adsorb to soil. A 2016 new use assessment on corn calculated freshwater aquatic taxa RQ's, with a fish and invertebrate acute and chronic RQ's well exceeding the listed and non-listed LOC's. Toxicity endpoints for aquatic organisms range well below 1 ppb.

Tetramethrin was assessed in the 2010 RED, which indicated that localized use patterns (aerosol cans, directed sprays and foggers) "do not allow exposure to be quantified with standard models," and so RQ's were not calculated for tetramethrin. Because the use pattern is "in individual, isolated areas, and

in small amounts,” the risk assessment concluded that “targeted application makes non-target exposure unlikely” except for terrestrial “invertebrates present at the time and place of localized spraying.”

The 2011 problem formulation for registration review reiterated the difficulty of calculating RQ’s for tetramethrin uses, stating that “(a)lthough there are uncertainties regarding the extent of use in residential settings, the cumulative exposure from multiple spot treatments across a particular setting is not likely to be substantial.” It stated that the greatest potential for risk to aquatic organisms could be from large scale applications with backpack sprayers, such as for outdoor nursery applications. The problem formulation described the potential for risk to endangered aquatic organisms, given the acute endpoint of 3.7 ppb for fish, and the potential that new data to be called in for aquatic and benthic invertebrates could show them to be more sensitive to tetramethrin

Aquatic Summary

Prior risk assessments completed for non-PWG pyrethroids concluded that they pose a similar pattern of risk to aquatic animals as the nine PWG pyrethroids quantitatively assessed in the current assessment. Those pyrethroids with uses that are expected to lead to aquatic exposure pose the greatest risk to freshwater and estuarine/marine invertebrates. The maximum acute and chronic RQ’s for freshwater and estuarine/marine invertebrates are generally in the tens or hundreds. Based on the historical RQ’s discussed above, there is generally no pattern that would indicate that the risk to aquatic invertebrates from pyrethroids included in the 2016 current assessment would be any different from those pyrethroids not included in the current assessment.

Acute and chronic toxicity data for benthic invertebrates were called in for most pyrethroids at the beginning of the registration review process, because available data indicated that these invertebrates are generally more sensitive to pyrethroid exposure than aquatic invertebrates living in the water column. Acute and chronic RQ’s based on these new toxicity endpoints are included in the 2016 current assessment. While benthic acute and chronic RQ’s were unexpectedly lower than water column RQ’s in the assessment, they still exceeded acute and chronic LOC’s. The results of the benthic invertebrate toxicity studies still further strengthen the conclusion that exposure of aquatic invertebrates to pyrethroids will lead to adverse acute and chronic effects.

Similarly to invertebrates, most pyrethroids have at least some uses with RQ’s that exceed the acute non-listed and chronic LOC’s for fish. However, these RQ’s are of lesser magnitude than RQ’s for aquatic invertebrates, in some cases by orders of magnitude. Most maximum acute RQ’s for freshwater fish are in the single digits, with the exception of cyfluthrins and tefluthrin. In general, acute RQ’s for estuarine/marine fish are in a similar range to those for freshwater fish, but with lower maximum RQ’s (all under 2.5). Chronic RQ’s for both freshwater fish and estuarine fish are in the same range, but freshwater fish have lower maximum RQ’s.

The risk to fish is similar for the nine pyrethroids in the current assessment and those that are not being quantitatively assessed. Again, there is generally no pattern that would indicate that the risk to fish from pyrethroids included in the 2016 current assessment would be any different from those pyrethroids not included in the current assessment. One of the PWG pyrethroids, deltamethrin, previously has not had an RQ exceeding an acute or chronic LOC for fish. In the current assessment, there were again no

exceedances for fish for deltamethrin, except for the acute LOC for endangered species for the mosquito adulticide use. Two non-PWG chemicals, d-phenothrin and prallethrin, have also not had fish LOC exceedances in the past. The highest historical acute and chronic RQ's among the nine PWG chemicals was for cyfluthrins, which also had exceedances in the current assessment, though they were not the highest. Tefluthrin stood out among those chemicals not included in the current assessment, with maximum acute and chronic RQ's of 21 and 75, respectively. Presumably these trends would hold if the unassessed chemicals were to be assessed again.

Avian Risk

The Agency's risk assessments indicate that acute and chronic risk to birds from pyrethroids is generally not expected, either due to lack of exposure or low toxicity. There are a few exceptions, with some reproductive toxicity seen for a few active ingredients. Other chemicals have non-definitive acute or chronic endpoints upon which RQ's that exceed LOC's were based.

Agency Levels of Concern (LOC) for birds are in table 16 below:

Table 16. Agency Levels of Concern (LOC) for Birds

Risk Presumption	RQ	LOC
Acute Risk	EEC/LC ₅₀ or LD ₅₀ /ft ² or LD ₅₀ /day	0.5
Acute Endangered Species	EEC/LC ₅₀ or LD ₅₀ /ft ² or LD ₅₀ /day	0.1
Chronic Risk	EEC/NOAEC	1.0

RQ's for birds described in previous risk assessments are presented in Figures 9 and 10 below. RQ's from assessments cited in the problem formulations, from assessments completed since the problem formulations, and from ESA assessments are included for all chemicals. The bibliography of the source assessments for these RQ's can be found in **Appendix A**. The RQ's are also presented in table format for each chemical, citing the source assessments, in **Appendix B**.

Figure 9 shows the ranges of acute avian RQ's for each chemical, all below 1.0. Only deltamethrin and tefluthrin exceeded the non-listed LOC of 0.5. Bifenthrin, cyhalothrins, deltamethrin, esfenvalerate, fenpropathrin, and tefluthrin exceed the listed species LOC of 0.1.

Figure 9.

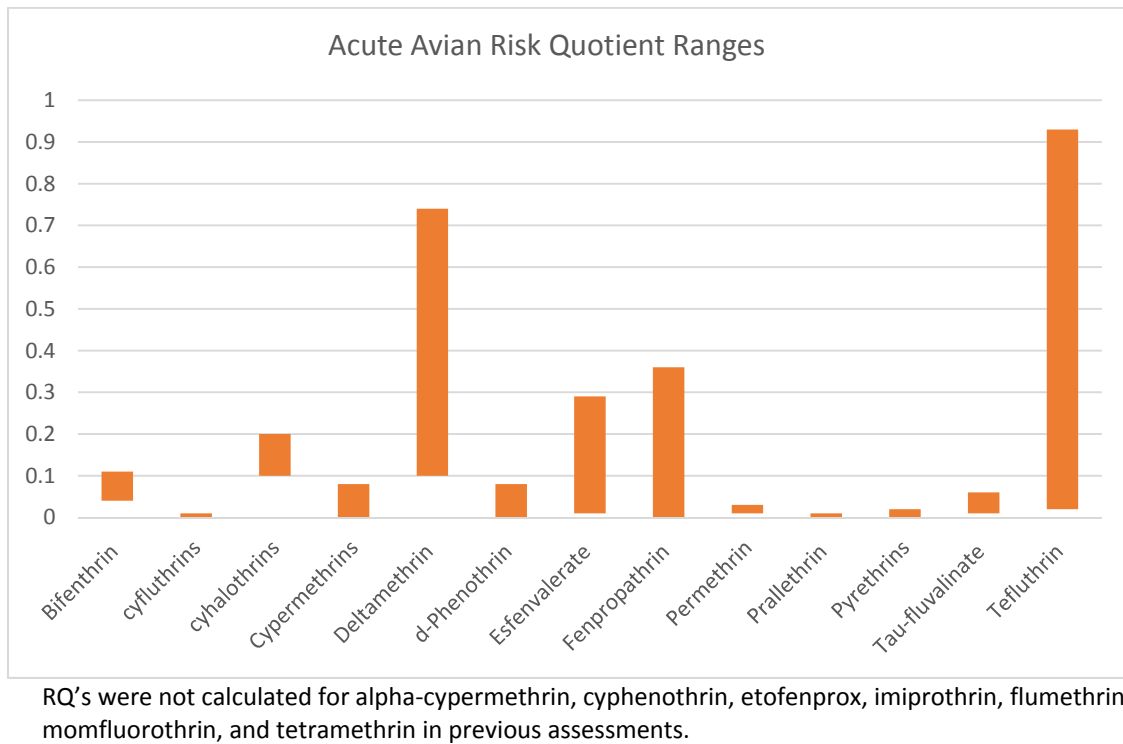
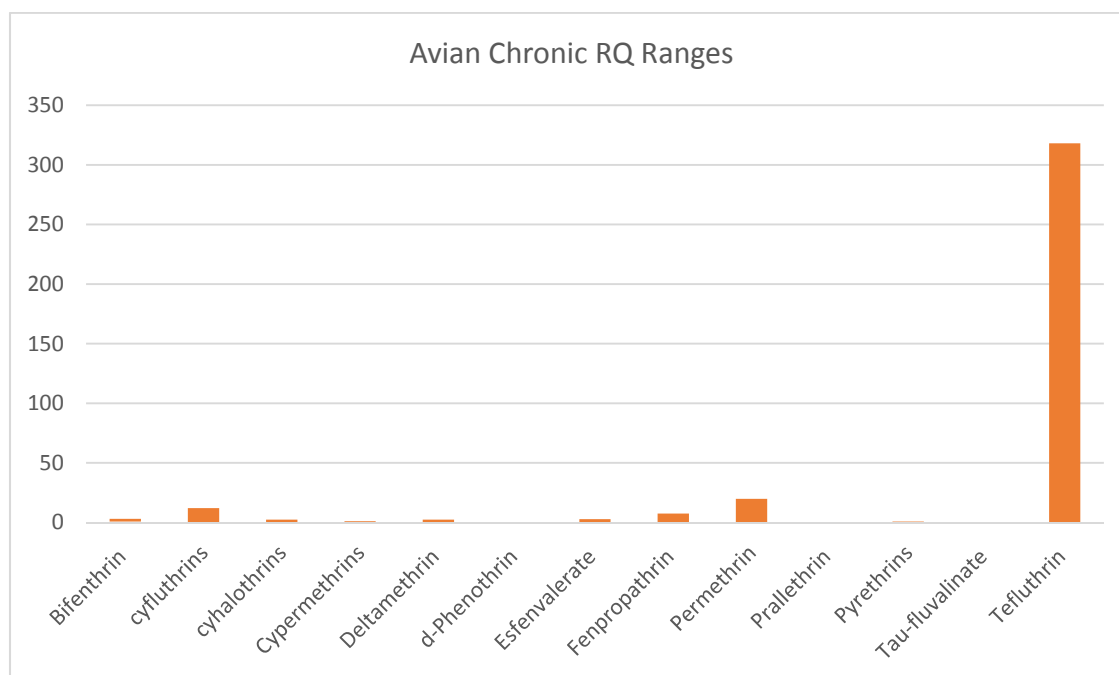


Figure 10 shows the ranges of chronic avian RQ's for each chemical. Bifenthrin, cyfluthrins, cyhalothrins, cypermethrin, deltamethrin, esfenvalerate, fenpropathrin, permethrin, and particularly tefluthrin (as a seed treatment) all had exceedances of the chronic LOC of 1.

Figure 10.



RQ's were not calculated for cyphenothrin, etofenprox, d-phenothrin, imiprothrin, flumethrin, momfluorothrin, and tetramethrin in previous assessments.

A brief description of the results of previous assessments for birds is presented below for each chemical. The bibliography of the source assessments can be found in **Appendix A**. The RQ's discussed below are also presented in table format for each chemical, citing the source assessments, in **Appendix B**.

Avian RQ's were not calculated in the 2007 **bifenthrin** new use risk assessment for use on root vegetables. The assessment concluded that "risk to terrestrial animals is probably minimal, due to a low toxicity." As discussed in the registration review 2010 Problem Formulation, the existing toxicity data suggests that bifenthrin appears to be slightly toxic on an acute basis to birds. This is based on a bobwhite quail (*Colinus virginianus*) single dose LD₅₀ of 1800 mg/kg bw (body weight) and an 8-day dietary LC₅₀ of 1280 mg/kg diet for the mallard duck (*Anas platyrhynchos*). In the reproduction studies, there were no effects at the highest concentration tested (NOAEC = 75 mg/kg diet) in the two one-generation chronic studies conducted on the bobwhite quail and mallard duck. The 2012 ESA assessment for endangered species in California calculated RQ's for three crops that exceeded the acute listed LOC, but no RQ's exceeded the non-listed acute LOC for birds. Although the risk assessment reported that the effects in the chronic studies "are not considered a biologically significant impairment of reproduction," risk quotients were calculated from the highest dose tested, some of which were above the LOC.

For **cyfluthrins**, the 2013 ESA assessment of risks to a number of endangered species in California. Cyfluthrins are practically non-toxic to birds on an acute basis, with non-definitive acute endpoints, and so acute RQ's were not calculated. For chronic effects, reproductive tests with cyfluthrin resulted in a NOAEC of 250 mg a.i./kg-diet (LOAEC = 1,000 mg a.i./kg-diet based on reduction in the number of eggs

laid, eggs set, fertilized eggs, 3-week viable embryos, hatchlings and 14-day survivors). Chronic RQ's that exceeded the LOC were calculated for non-agricultural uses of cyfluthrins, and the maximum non-agricultural RQ's were for airport/landing strip use. Chronic RQ's calculated with maximum estimated residues ranged as high as 12.1. For this assessment, 10 applications were assumed, because the maximum number of applications was not specified on at least one product label. In a previous assessment on multiple uses in 2004, acute and chronic RQ's were well below the LOC. In a 2006 assessment on tobacco, RQ's were zero.

An avian reproduction study on mallards submitted for registration review and reviewed by the Agency with beta-cyfluthrin showed no mortality or signs of toxicity in any of the treatment groups, for feed consumption, body weight, or reproductive parameters and there were no statistically significant differences in egg shell thickness at any treatment level. The NOAEC was 269 mg ai/kg diet (MRID 48350615).

Cyhalothrins (gamma and lambda), are considered to be slightly toxic or practically non-toxic to waterfowl and upland game birds with acute or subacute exposures. Results from a lambda-cyhalothrin mallard duck reproduction study indicated that no reproductive parameters were affected at levels up to 30ppm. In a 2002 assessment on multiple new uses for lambda cyhalothrins, acute RQ's for birds were well below the LOC's, ranging from <0.1 – 0.2. Some of the chronic RQ's exceeded the chronic LOC (≥ 1), with a range from <0.1 to 2.5. However, because this was calculated from a study in which no reproductive effects were seen, the potential for actual chronic risk is uncertain.

An avian acute dietary study on passerines with lambda cyhalothrin submitted for registration review found an LC₅₀ of 542 mg ai/kg diet (MRID 49587201), which would classify lambda cyhalothrin as moderately toxic to passerines on an acute dietary basis.

In the 2008 **cypermethrin (racemic)** RED, acute and chronic avian RQ's were well below the LOC for all size classes and food items for agricultural crops. In the 2012 registration assessment for **alpha cypermethrin**, acute RQ's were not calculated because only non-definitive acute and sub-acute toxicity endpoints were available, but chronic RQ's were well below the LOC. In a 2006 new use assessment on many crops for **zeta cypermethrin**, all acute (dose-based and dietary-based) RQ's were below the acute listed and non-listed species LOC's for all crop uses. Chronic, dietary-based RQ's for birds were all below the LOC for chronic risk. It was not possible to calculate a chronic dose-based RQ for birds because there were no acceptable dose-based toxicity values for birds available. The 2013 zeta cypermethrin new use assessment on poultry houses also found RQ's that were well below the LOC for acute risk to birds, with chronic risk just exceeding the LOC at an RQ of 1.01.

The available data for cypermethrins is discussed in the 2012 Problem Formulation. Cypermethrins are practically non-toxic to birds on an acute oral basis. This is based on the results of the single acute oral toxicity study available. The acute oral LD₅₀ value for bobwhite quail is >2000 mg a.i./kg-bw and no clinical signs of toxicity were observed at any treatment level (MRID 44546024). Cypermethrins are practically non-toxic to avian species on an acute dietary basis based on the results of the sub-acute dietary toxicity studies, where the LC50 is greater than 2,634 mg a.i./kg-diet for mallard duck (MRID 00090071). Data on acute avian oral toxicity with the cypermethrins were required in registration review

for passerine species. Cypermethrins are slightly toxic to birds on a chronic basis, based on the results of avian reproduction study, which showed no adverse effects at 50 mg a.i./kg-diet, the highest dose tested.

Cyphenothrin is categorized as practically nontoxic to birds on a subacute dietary exposure basis, with no mortality observed at the highest dose tested (5620 ppm). Avian reproduction studies have not been submitted for cyphenothrin, and were not required for registration review. Birds are not expected to be exposed to cyphenothrin, because there are no registered outdoor uses. As a result avian RQ's had not been calculated as of the 2009 Registration Review Problem Formulation, or in the 2013 new use assessment on a spray product for dogs. The avian acute oral study on passerines and an avian reproduction study called in for registration review were both waived for cyphenothrin.

Deltamethrin is practically nontoxic on an acute basis to birds based on a bobwhite quail (*Colinus virginianus*) single dose LD₅₀ > 2250 mg/kg bw (MRID 00158273) and an 8-day dietary LC₅₀ > 4640 mg/kg diet for the mallard duck (MRID 00060723), as discussed in the 2010 Problem Formulation. In the reproduction studies, there were no effects at the highest concentration tested (NOAEC = 450 mg/kg diet) in the two one-generation chronic studies conducted on the bobwhite quail and mallard duck (MRIDs 42114808 and 42114809). Based on the toxicity, risk to birds from exposure to deltamethrin is not expected.

The 2013 ESA assessment for endangered species in California calculated RQ's based on the non-definitive acute endpoints described above, and the no-effect level at the highest dose from the chronic studies. The RQ's for ant mound treatments were <0.74 for acute exposure, and 2.34 for chronic exposure, for maximum estimated residues consumed on short grass by small birds. Although the implications for risk from these LOC exceedances is uncertain, this was the only use which led to exceedances. Most recently, risk to birds was not indicated in a 2014 new use mosquito adulticide assessment based on toxicity and anticipated exposure.

An avian acute oral study with a passerine species (canary) submitted for registration review indicated that deltamethrin is not toxic to songbirds, as an LD₅₀ could not be established at the highest dose tested, 2000 mg/kg-bw. This is consistent with previous studies on the toxicity of deltamethrin to birds.

D-phenothrin, is classified as practically nontoxic to birds on an acute oral and subacute dietary exposure basis. In the 2008 RED, the toxicity values cited (oral LD₅₀ >2,510 ppm and dietary LC₅₀ >5,000 ppm) did not produce endpoints at the highest doses tested. Because of this, risk to birds was not assessed in the 2008 RED. RQ's calculated based on these studies were no higher than <0.08 in a 2012 new use misting assessment. However no data were available to assess the potential for effects to birds from chronic exposure to d-phenothrin at the time of this assessment, and so chronic risk to birds was not precluded.

D-phenothrin was reviewed in 2013 for a new use as a mosquito adulticide product co-formulated with piperonyl butoxide. Since d-phenothrin was already registered as a mosquito adulticide and addressed in the RED, and the same rate was proposed, this assessment relied on the conclusions of the 2008 RED.

Acute avian studies indicate that **esfenvalerate** is moderately toxic to birds. The available data described in the 2010 Problem Formulation indicate that the acute oral LD₅₀ for bobwhite quail were 381 mg/kg-bw for the SS-isomer and >2000 mg/kg-bw for all isomers (MRID 41698401 and 41891909). The 2008 ESA endangered species assessment for the California red-legged frog calculated acute RQ's, using maximum estimated residues consumed on short grass by small birds, that ranged as high as 0.29 which is below the non-listed acute LOC. Chronic RQ's ranged from 0.27 to 2.75, exceeding the chronic LOC for some uses, based on a reproduction study with fenvalerate since there was no avian chronic study for esfenvalerate available. However, because effects were seen at the lowest dose tested in the fenvalerate study, and the esfenvalerate NOAEC is likely lower, the risk to birds is potentially greater than indicated by the RQ's.

An acute passerine study submitted for registration review and reviewed by the Agency found an oral toxicity LD₅₀ of 200 mg ai/kg-bw (MRID 49074601), consistent with previous toxicity studies.

Etofenprox is classified as practically non-toxic to avian species on an acute oral exposure basis. The LD₅₀ for mallard duck is >2,000 mg/kg body weight (BW). The LC₅₀ values for both avian species are greater than the highest treatment level of 4,890 mg/kg-diet; therefore, etofenprox is classified as practically non-toxic to birds on a subacute dietary exposure basis. The chronic avian NOAEC values for bobwhite quail and mallard duck are 1,017 and 1,010 mg/kg-diet, respectively. The 2007 problem formulation included a screening assessment of the outdoor yard and patio fogger treatment, which found acute RQ's of zero for birds, though no chronic data was available. Acute and chronic RQ's were not calculated in the 2008 new use assessment for uses on both a granular application to rice paddies and an ultra-low volume aerial spray as a mosquito adulticide, because only non-definitive acute and chronic toxicity endpoints are available for birds. RQ's were not calculated in the 2010 new use assessment because the rates were lower than the 2008 assessment.

For **fenpropathrin**, the 2008 new use assessment indicated that for single broadcast applications, no avian acute level of concern was exceeded. The acute oral LD₅₀ is 1089 mg/kg for fenpropathrin, which is categorized slightly toxic to birds on an acute oral basis. Subacute dietary LC₅₀'s are greater than 5,000 ppm, therefore fenpropathrin is categorized practically nontoxic to birds on a subacute dietary basis. However, in this assessment chronic LOC's were exceeded at the maximum single application rate for all food items other than seeds (RQ's ranged from 0.1 to 3.8). For multiple broadcast applications, avian chronic levels of concern were exceeded for all food items other than seeds (RQ's ranged from 2.3 to 7.0). In a 2013 new use assessment on multiple crops, acute RQ's did not exceed the LOC, but chronic RQ's ranged from 0.13-7.48 and exceeded the listed and non-listed LOC's.

An avian acute oral study submitted for registration review found an acute oral LD₅₀ of > 70 mg ai/kg bw, classifying fenpropathrin as practically non-toxic to the zebra finch on an acute oral basis based on mortality. There were signs of toxicity in all dose groups but no treatment related effects on food consumption and body weight. However, this study is classified as supplemental due to regurgitation in all dose groups (MRID 49076501).

Flumethrin is registered for pet collar use only and so RQ's were not calculated, since exposure to birds is expected to be negligible.

Acute toxicity data indicate that **imiprothrin** is practically non-toxic to birds with an LD₅₀ > 2250 mg ai/kg bw. Acute dietary toxicity testing indicates that imiprothrin is practically non-toxic to birds with LC₅₀ > 5680 ppm ai for bobwhite quail and mallard duck. No RQ's have been calculated, because although there were uncertainties regarding the extent of use in residential settings, the outdoor crack and crevice uses assessed in 2006 were not expected to result in substantial environmental exposure to non-target terrestrial organisms. In addition, chronic risk quotients have not been calculated due to a lack of data.

Momfluorothrin is registered for use in aerosol cans for residential crack and crevice treatment, and application to wasp and hornet nests. The results of acute oral toxicity testing for momfluorothrin indicate that it is practically nontoxic to avian species on an acute oral basis. The acute oral LD₅₀ value for bobwhite quail is >2250 mg a.i./kg-bw and no clinical signs of toxicity were observed at any treatment level (MRID 49019971). The results of the sub-acute dietary toxicity studies available for momfluorothrin indicate that it can be categorized as practically non-toxic to avian species on an acute dietary basis. The LC₅₀ for momfluorothrin is greater than 5,620 mg a.i./kg-diet for mallard duck (MRID 49019977) and bobwhite quail (MRID 49019975). Because of the application method and low toxicity, no RQ's were calculated. Dietary exposure to food items containing momfluorothrin residues from spray drift or large quantities of dispersed product is unlikely, and acute risk to birds is expected to be low.

The risk assessment for the registration of momfluorothrin indicated that "(c)hronic avian reproduction testing with northern bobwhite found effects at all concentrations tested. Since a definitive no-effect concentration was not determined, it is not possible to define a threshold at which the exposure would not result in risk exceeding the level of concern. However, since the upper bound T-REX estimates for short grass would be approximately 21 ppm for the scenario involving uniform distribution of an entire can's contents over a 200 square foot area, and since 21 ppm is approximately an order of magnitude less than the lowest dose tested in the bobwhite avian reproduction study, there is a good margin of safety considering that pyrethroids as a class are not known to have chronic avian toxicity concerns. Chronic risk to avian species is expected to be low." Risk quotients were not calculated in 2014 assessment.

A momfluorothrin avian acute oral study with a passerine species (zebra finch) submitted for registration review, although not yet reviewed, suggests that momfluorothrin is not significantly toxic to songbirds, as an LD₅₀ could not be established at the highest dose tested, 2250 mg/kg-bw. This is consistent with previous studies on the toxicity of pyrethroids to birds.

For **permethrin**, acute oral toxicity studies indicate that it is practically non-toxic to avian species with an LC₅₀ value for mallard duck, Japanese quail, starling, and ring-necked pheasant ranging from >2,000 to >42,706 mg a.i./kg body weight. Sub-acute dietary toxicity studies suggest it is practically non-toxic to birds on a sub-acute dietary basis with LC₅₀ value for mallard duck, bobwhite quail, and ring-necked pheasant ranging from >5,200 to >23,000 mg a.i./kg diet. Avian reproduction studies discussed in the 2011 Problem Formulation indicate that permethrin may have adverse effects at higher levels of exposure. In the 2009 RED, avian acute RQ's for permethrin are below the acute and endangered species LOC's and the chronic RQ's are below the chronic LOC at registered maximum application rates for all forage items for all agricultural scenarios (considered to be worst case). The mosquito adulticide scenario was not specifically assessed. In the 2008 ESA assessment, the highest chronic RQ's were for

birds feeding on short grass in the residential turf and ornamentals scenario, with the lowest RQ's for birds under the mosquito adulticide scenario (RQ's ranging from <0.01 to 0.12)

For **prallethrin**, the 2014 risk assessment on the mosquito adulticide use over agricultural areas found avian acute dose-based RQ's are all <0.01, and avian chronic dietary-based RQ's range from <0.01 to 0.01, both below the acute and chronic LOC's. Avian acute dietary-based RQ's were not calculated because the sub-acute dietary toxicity endpoints are non-definitive (*i.e.*, there were no effects up to and including the highest dose tested). Instead, the most sensitive, non-definitive acute dietary-based toxicity endpoint for birds was compared directly to avian dietary-based EECs. Dietary-based EECs are over three orders of magnitude less than the most sensitive, non-definitive avian sub-acute dietary toxicity endpoint. Collectively, these analyses suggest that the potential for risk to birds is low.

Pyrethrins are practically non-toxic to avian species on an acute oral and dietary basis (oral LD₅₀ >2,000 mg/kg bw; dietary LC₅₀ >5,620 mg/kg diet). Reproductive toxicity data are not available or were ever required. Acute and chronic risk was below the LOC's for listed and non-listed species in the RED, based on a crop use scenario considered to be representative of the maximum use rates of pyrethrins. The mosquito adulticide use was not specifically evaluated. Chronic risk was estimated using the NOAEC for bobwhite quail (125 mg/kg/diet).

A newly submitted registration review toxicity study is consistent with the previous understanding that pyrethrins are not toxic to birds. Although not yet reviewed by the Agency, the avian reproduction toxicity study with quail did not establish toxicity endpoints at the highest doses tested.

For **tau-fluvalinate**, an acute LD₅₀ was not established at the highest dose tested, and the subacute dietary endpoint was high enough to conclude that there is no acute risk to birds. The chronic avian studies had no effects observed at the highest dose tested of 900 ppm. Tau-fluvalinate is classified as practically non-toxic to birds. In the 2005 RED, all of the acute and chronic RQ's were below the LOC's calculated for birds using maximum EECs following both acute and chronic exposure, based on an acute LC₅₀ of 5627 ppm and a chronic NOEC of 900 ppm.

Tefluthrin is classified as practically nontoxic to slightly toxic to birds based on the available acute oral and subacute dietary exposure studies; however, an acute oral study with the house sparrow submitted for registration review provisionally indicates that tefluthrin is more toxic to passerines. The acute RQ's calculated in the 2010 new use assessment for beet seed treatment were calculated with an acute study which could not establish an endpoint at the highest dose tested (non-definitive). Therefore, although this resulted in some RQ's above the acute LOC, the potential for actual acute risk to birds is uncertain.

As the discussed in the 2012 Problem Formulation, the NOAECs for birds in reproduction studies are also the highest dose tested, as no effects were observed. Therefore, while chronic RQ's calculated with this value exceed the chronic LOC, the potential for actual chronic risk is uncertain. In addition, the 2010 assessment assumes that tefluthrin-treated seed represents 100% of the dietary needs for birds. In reality, birds do not feed on tefluthrin-treated seed for extended periods of time as they avoid the treated seed after the first consumption. Acute and chronic risk therefore, may not be as high as that predicted in the 2010 assessment. In a 2016 new use assessment on a higher rate for corn in-furrow

treatments, the acute RQ was 0.46, just below the non-listed LOC, and the chronic RQ's ranged from <0.01- 3.14, exceeding the listed and non-listed LOC's. However, these in-furrow and T-band sprays are mostly incorporated into the soil and so there is minimal exposure on the surface. The sprays are close to the ground, and drift is minimal. Exposure to the full rate is likely variable.

Tetramethrin is practically non-toxic to birds on the basis of acute oral and dietary studies. As discussed in the 2011 Problem Formulation, the bobwhite quail oral toxicity study (MRID 41609604) resulted in an LD₅₀ >2250 mg/kg bw. Four avian dietary toxicity studies, two with bobwhite quail and two with mallard, (MRIDs 00121262, 00121268, 41609605, 41609604) resulted in an LC₅₀ >5620 mg/kg diet. RQ's were not calculated in the 2010 RED. It was concluded that the use of tetramethrin as a spot treatment in residential and/or commercial settings is unlikely to result in extensive treatment of potential feed items. An avian acute oral study called in for registration review was waived for tetramethrin.

Avian Summary

Based on the results of previous risk assessments, the low potential for risk to birds is consistent across pyrethroid insecticides, with few exceptions. Some pyrethroids, such as cyphenothrin, flumethrin, and momfluorothrin, have use profiles which make exposure to birds very unlikely. For other pyrethroids, acute risk to birds is generally not expected, due to low toxicity. Three pyrethroids, bifenthrin, deltamethrin, and tefluthrin, have RQ's which exceed the non-listed avian acute LOC. However, because these were calculated using studies which did not establish an endpoint at the highest dose tested, the potential for actual acute risk from exposure to these chemicals is uncertain.

Similarly, chronic risk to birds from exposure to pyrethroids is generally not expected, as RQ's for pyrethroids to which birds might be exposed are mostly below the chronic LOC. However, avian reproduction studies for two pyrethroids, cyfluthrins and fenpropathrin, indicated reproductive effects and RQ's exceed the level of concern. Chronic risk resulting from non-agricultural uses of cyfluthrins is based on a reproduction study showing frank reproductive effects in birds. A reduction in the number of live embryos at 3 weeks was observed in the fenpropathrin study.

Other pyrethroids had chronic RQ's above the LOC, including bifenthrin, cyhalothrins, zeta-cypermethrin, deltamethrin, and tefluthrin. However, effects were not seen at the highest dose tested in the avian reproduction studies on which the RQ's were based. Therefore, the potential for actual chronic risk for these pyrethroids is also uncertain. Esfenvalerate and permethrin exceeded the LOC in the ESA assessments.

Mammal Risk

The Agency's risk assessments indicate that, except for the cypermethrins and pyrethrins, the PWG chemicals and associated isomers have at least one RQ that exceeds the acute non-listed and chronic mammalian LOC's. Only one of the non-PWG pyrethroids, tefluthrin, has an RQ exceeding the acute non-listed mammalian LOC, and two, tefluthrin and tau-fluvalinate, have RQ's exceeding the chronic mammalian LOC.

Agency Levels of Concern (LOC) for wild mammals are in Table 17 below:

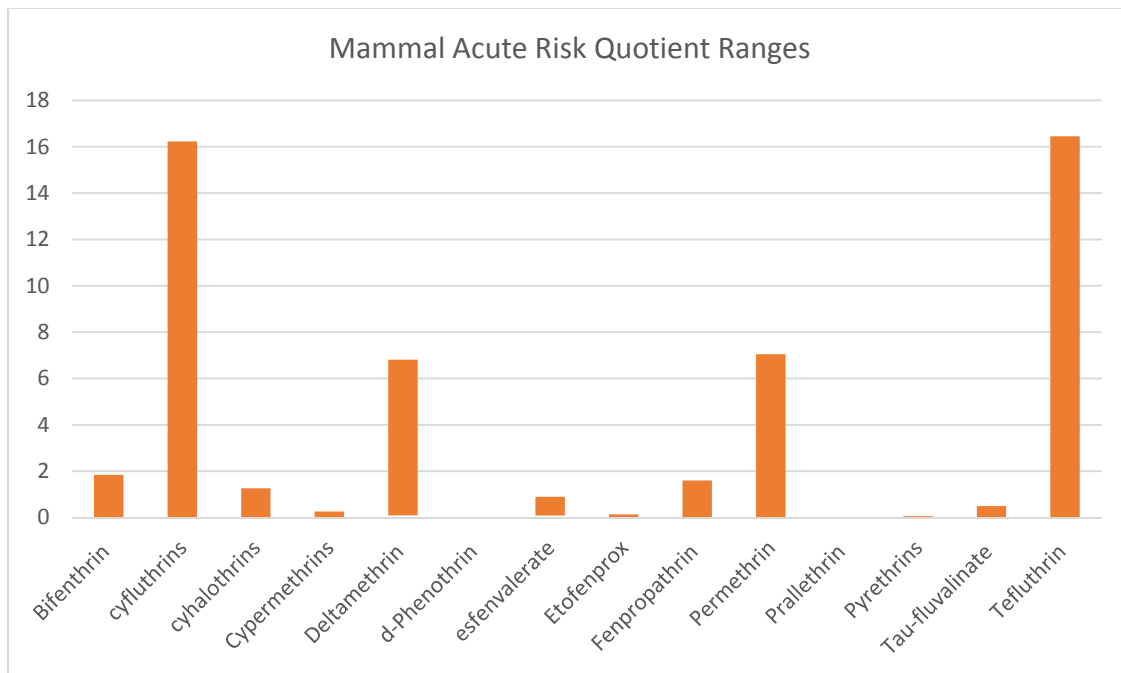
Table 17. Agency Levels of Concern (LOC) for Wild Mammals

Risk Presumption	RQ	LOC
Acute Risk	EEC/LC ₅₀ or LD ₅₀ /ft ² or LD ₅₀ /day	0.5
Acute Endangered Species	EEC/LC ₅₀ or LD ₅₀ /ft ² or LD ₅₀ /day	0.1
Chronic Risk	EEC/NOAEC	1.0

RQ's for mammals described in previous risk assessments are presented in Figures 11 and 12 below. RQ's from assessments cited in the problem formulations, from assessments completed since the problem formulations, and from ESA assessments are included for all chemicals. The bibliography of the source assessments for these RQ's can be found in **Appendix A**. The RQ's are also presented in table format for each chemical, citing the source assessments, in **Appendix B**.

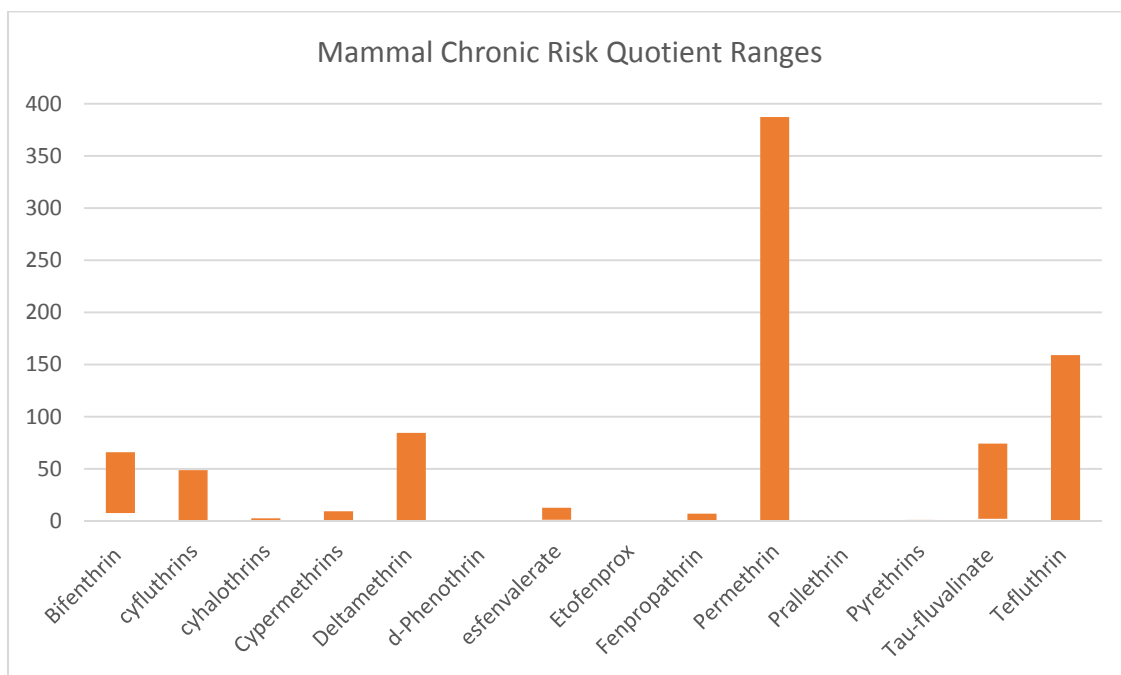
Figure 11 shows acute mammalian RQ ranges across chemicals. Only cypermethrins, pyrethrins, d-phenothrin, and etofenprox do not have non-listed LOC exceedances. Only d-phenothrin has no listed species LOC exceedances.

Figure 11.



The range of chronic mammalian RQ's across chemicals is shown in Figure 12. There were large chronic LOC exceedances are for cyfluthrins, deltamethrin, and permethrin from the ESA assessments for those chemicals. Bifenthrin, tau-fluvalinate, and tefluthrin also had larger exceedances.

Figure 12.



A brief description of the results of previous assessments for mammals is presented below for each chemical. The bibliography of the source assessments can be found in **Appendix A**. The RQ's discussed below are also presented in table format for each chemical, citing the source assessments, in **Appendix B**.

The 2012 **bifenthrin** ESA assessment for endangered species in California calculated risk quotients with maximum estimated residues, which exceeded the acute listed and non-listed LOC's for small mammals eating short grass. RQ's which exceeded the non-listed LOC for agricultural uses ranged between 0.51 and 0.97. Risk quotients for non-agricultural uses which exceeded the non-listed LOC were within the same range, except for use on ornamentals and shade trees, which had RQ's as high as 1.84.

A 2-generation reproduction study with rats (MRID 00157225) resulted in a LOAEL of 60 ppm and a NOAEL of 30 ppm based on dose-related lower weights in females during first and second lactation periods and second gestation, and a significant decrease in mean absolute ovarian weight. The reviewer found the test to show no indications of any dose-related trends with respect to reproduction. Chronic dose-based RQ's for small mammals eating short grass exceeded the LOC for both agricultural and non-agricultural uses, ranging as high as 66 for use on ornamentals and shade trees.

Acute and chronic RQ's which exceeded the non-listed LOC's were calculated for **cyfluthrins** in the 2013 ESA assessment of risks to a number of endangered species in California. The maximum agricultural RQ's were for cotton. Acute RQ's calculated with maximum estimated residues ranged as high as 2.84; chronic RQ's calculated with maximum estimated residues ranged as high as 2.12. The maximum non-agricultural RQ's were for airport/landing strip use. Acute RQ's calculated with maximum estimated residues ranged as high as 16.23; chronic RQ's calculated with maximum estimated residues ranged as high as 48.7. In both cases, 10 applications were assumed, because the maximum number of applications was not specified on at least one product label.

Prior to this, cyfluthrins were assessed in 2004 for multiple new agricultural uses and acute RQ's ranged from 0.5-0.89, while chronic RQ's were <1.0. A new use assessment on tobacco in 2006 found low acute RQ's that just met or exceeded the LOC, ranging from zero to one for acute risk and from zero to 0.01 for chronic risk.

The **cyhalothrins** (lambda and gamma) were assessed in 2002 for a wide range of new agricultural uses, including vegetables, wheat and other grains, stone fruits, tree nuts, tobacco, termites, tree plantations, and nurseries. Acute RQ's ranged from < 0.01 to 1.26 and chronic RQ's ranged from < 0.1 to 2.5, with most of the uses just exceeding the LOC.

Cypermethrin (racemic) was assessed in the 2005 RED, and the EFED chapter was later revised in 2006 to address comments on the terrestrial animal assessment, and included in the final 2008 RED. Alpha cypermethrin was assessed as a new active ingredient when it was first registered in 2012. Zeta-cypermethrin was assessed in 2006 for multiple new crop uses, turf and ornamentals, and a termiticide use, and in 2013 for a new use on poultry houses.

For racemic cypermethrin, the highest mammal acute RQ's ranged from <0.01-0.19 (dose based) and the highest chronic RQ's ranged from 0.04-9.27 (dose-based) for the cotton use. Other uses had similar but slightly lower RQ's. Alpha cypermethrin acute RQ's ranged from <0.01 -0.16 (dose-based) and chronic

RQ's ranged from < 0.01-2.71 (dose-based) in the registration assessment. In the 2006 assessment on multiple new uses for zeta-cypermethrin, spray application acute RQ's ranged from <0.01-0.16, and chronic ranged from 0.01-2.73. Acute RQ's for granular applications were higher, ranging from 0.04-0.83. Dietary based chronic RQ's for spray applications were lower, and ranged from 0.01-0.031. In the poultry house assessment, acute RQ's ranged from 0.001-0.26 and chronic RQ's ranged from 0.03-4.39 (dose-based). This exposure is from poultry litter use as a crop fertilizer to terrestrial environments, but the assessment concluded that the incremental exposure from this use does not substantially alter the risk conclusions for mammals from zeta-cypermethrin.

Cyphenothrin is primarily for indoor use, and RQ's have not been calculated for mammals. Cyphenothrin is moderately toxic to mammals on an acute oral exposure basis (LD 50 is 318 mg/kg), but there is limited information on the effects of chronic exposure to mammals.

Acute and chronic toxicity studies for **deltamethrin** resulted in endpoints in the range of expected environmental concentrations. The 2013 deltamethrin ESA assessment for endangered species in California calculated risk quotients with maximum estimated residues. Only the use on ornamentals/shade trees and ant mound applications resulted in RQ's which exceeded the acute non-listed LOC, at 0.74 and 6.81, respectively, for small mammals eating short grass.

Several crop uses had chronic dose-based RQ's estimated with maximum estimated residues for small mammals eating short grass which exceeded the chronic LOC. The highest of these RQ's was 2.0. Ornamental and non-crop uses had higher chronic dose-based RQ's; application to ant mounds resulted in an RQ of nearly 85, which was almost 10 times higher than the next highest RQ, for ornamental plants. Agricultural RQ's were in the 1.31 to 2.03 range. The 80 ppm NOAEC for mammals was based on severe effects, including mortality, at a dose equivalent to 320 ppm in the diet. The mosquito adulticide use was not assessed in the ESA assessment, and in the 2014 mosquito adulticide assessment, risk to mammals was not indicated based on toxicity and anticipated exposure.

In the **d-phenothrin** RED, because the oral LD₅₀ was greater than 5,000 ppm toxicity, no acute RQ's were calculated because it is practically nontoxic to mammals on an acute basis. Chronic RQ's were calculated, and were 0.01 and below. The 2012 assessment on a new outdoor misting use did not indicate acute or chronic risk to mammals either, with acute RQ's below 0.01, and chronic RQ's of 0.01 or less.

D-phenothrin was reviewed in 2013 for a new use as a mosquito adulticide product co-formulated with piperonyl butoxide. Since d-phenothrin was already registered as a mosquito adulticide and addressed in the RED, and the same rate was proposed, this assessment relied on the conclusions of the 2008 RED.

Studies submitted for the registration review of d-phenothrin include a subchronic neurotoxicity study in the rat (MRID 49173694) and a non-guideline prenatal developmental toxicity study in the rabbit (MRID 49173605), which have been reviewed by the Agency. The neurotoxicity study showed no adverse effects at the highest dose tested, giving a NOAEL of 10,000 ppm for males and 3,000 ppm for females. The developmental toxicity study resulted in no hydrocephalus in the fetuses, which had been observed in previous studies.

The problem formulation for **esfenvalerate** indicates that risks were found for mammals in 1995 and 1997 assessments. The 2008 ESA endangered species assessment for the California red-legged frog

calculated some acute and chronic mammal RQ's for esfenvalerate that exceeded the non-listed LOC's. The acute RQ's for agricultural uses were all below the non-listed LOC, but the RQ for "general outdoor surfaces" calculated with maximum residues for small mammals eating short grass was 0.90. The dose-based chronic RQ's ranged from 1.24 to 5.53 for crop uses, as calculated with maximum residues for small mammals eating short grass. The similarly calculated RQ for "general outdoor surfaces" was 12.62. Effects seen in the chronic toxicity study included dermal lesions and decreased weight in parent rats, and decreased weight and litter size in pups.

The 2007 **etofenprox** problem formulation included a screening assessment of the potential risk from outdoor yard and patio fogger treatment, and found acute and chronic RQ's of zero for mammals. The problem formulation states that "etofenprox is practically non-toxic to mammals with an $LD_{50} > 5000$ mg/kg-bw (the highest concentration tested). There are a number of longer-duration toxicity tests on mammals, including a chronic dietary study that indicated a NOAEL of 3.7 mg/kg-bw/day and a corresponding LOAEL of 25.5 mg/kg-bw/day. The endpoint chosen was increased thyroid weight, which may or may not relate directly to growth, survival, and reproduction." A 2008 etofenprox new use assessment on rice and wide area mosquito control determined that no acute mortality and/or chronic growth, reproductive, or survival effects were observed in any of the mammalian studies at the highest concentrations/doses tested and so RQ's were not calculated. A 2010 new use assessment on mound building ant control also did not assess risks to mammals.

Fenpropathrin is highly acutely toxic to mammals ($LD_{50} = 48.5$ mg/kg), and reproductive effects were seen in the chronic study, with a LOAEL of 250 ppm and a NOAEL of 25 ppm. In a 2008 assessment on multiple new uses, chronic risk to mammals was assumed to be the same as that to birds because the reproductive NOAEL in the rate was 25 ppm, the same for birds. Acute RQ's ranged from 0.0-0.02 assuming multiple applications, and from 2.3-7.0 for chronic exposure, assuming multiple applications. Assuming a single application, there were chronic exceedances with RQ's ranging from 0.1-3.8. The 2013 assessment on multiple new uses found acute RQ exceedances for non-listed species for all uses except barley, ranging from <0.01-1.6. Chronic RQ's ranged from 0.2 to 26, including all assessed uses.

RQ's have not been calculated for **flumethrin**, because the use in pet collars is not expected to lead to direct outdoor exposure to wild mammals.

Imiprothrin is slightly toxic to mammals, with an acute endpoint of 900 mg/kg-bw/day. No chronic mammalian study has been submitted. No RQ's have been calculated, because although there were uncertainties regarding the extent of use in residential settings, the outdoor crack and crevice uses assessed in 2006 were not expected to result in substantial environmental exposure to non-target terrestrial organisms.

Momfluorothrin is registered for use in aerosol cans for residential crack and crevice treatment, and application to wasp and hornet nests. Momfluorothrin is not acutely toxic to mammals, as indicated by an acute oral rat study in which an endpoint could not be established at the highest dose tested; acute RQ's were not calculated in the registration assessment. A chronic endpoint was established at 200 ppm in feed, based on decreased pup weight in both generations of a two generation rat reproduction study. Because momfluorothrin is formulated in aerosol cans, RQ's were not calculated. However, the risk assessment indicated that because the equivalent of 9 aerosol cans of momfluorothrin would have to be applied in a 200 square-foot area to achieve an exposure of concern, chronic risk to mammals is not anticipated.

Risk to mammals was assessed for **permethrin** in the 2009 RED, based on the EFED chapter that was updated in 2006. Using the endpoint from submitted acute studies available at the time, 2280 mg a.i./kg-bw, there were no RQ's that exceed the non-listed acute LOC. Agricultural scenarios were assessed and considered to be representative of worst case; the mosquito adulticide use was not specifically assessed.

However, more sensitive acute toxicity data for Wistar rats was found through a literature search for the 2008 ESA assessment for a number of endangered species in California. Adjusting for body weight for use in the Agency's exposure model, the acute endpoint used was 152.28 mg/kg-bw. Acute RQ's calculated with this endpoint for small mammals and maximum estimated residues exceeded the non-listed acute LOC, with a range up to 7.05.

Chronic data submitted to the Agency did not result in reproductive effects, but a NOAEC of 1000 ppm was established due systemic effects at the highest dose, which included tremors in parent and pups in the three-generation rat reproduction study. Risk quotients calculated with this endpoint did not exceed the chronic LOC in the RED, but dose based RQ's exceeded the chronic LOC, ranging up to 2.57 for the assessed crop scenarios.

A much more sensitive study with white mice was found through a literature search for the 2008 ESA assessment. The assessment states that this study might overestimate the effects of permethrin exposure, because it was administered by gavage, while normally two-generation reproduction studies are performed administering the chemical through treated feed. However, in order to be conservative in a risk assessment for endangered species, a chronic endpoint of 2.77 mg/kg-bw was used for modeling purposes. Chronic RQ's for small mammals with maximum estimated residues ranged as high as 387. The highest RQ's were for mammals that feed on short grass under the residential turf and ornamental exposure scenario, and the lowest RQ's were for mammals that feed on fruits/pods/seeds/large insects under the mosquito adulticide exposure scenario (RQ's ranging from <0.01 to 0.04 acute, and from 0.01 to 2.32 chronic).

Prallethrin was assessed in a 2014 new use assessment on a wide area mosquito use. This assessment revised older 2003-2005 assessments and included revisions to EEC's. Mammalian acute dietary-based RQ's were not calculated because of the lack of an acute dietary toxicity endpoint. Mammalian dose-based acute and chronic RQ's and dietary-based chronic RQ's are all <0.01.

Pyrethrins was assessed in the RED, and acute mammal RQ's were well below the LOC, ranging from 0.0-0.06. Chronic RQ's ranged from 0.04 to 0.97, just below the LOC. The RED assessment is based on a crop use scenario considered to be representative of the maximum use rates of pyrethrins. The mosquito adulticide use was not specifically evaluated.

The Problem Formulation for **tau-fluvalinate** registration review reported that previous risk assessments indicated chronic risk to mammals. The acute mammalian risk assessment in the RED calculated RQ's for carrots and ornamentals. One RQ using upper bound Kenaga values was equal to the listed acute LOC of 0.1, for 12 applications to ornamentals at the highest rate and the minimum retreatment interval, and the rest were below the listed and non-listed LOC's. Using upper-bound Kenaga values and a rat reproduction dose based NOAEL of 1.9 mg/kg/day, chronic RQ's ranged from 2.12-74.18. RQ's were also calculated with a dietary NOAEC of 25 ppm with upper bound Kenaga values, which gave RQ's ranging from 0.17-13.00. The highest RQ's were for the ornamental use, for 15g mammals eating short grass.

The two-generation reproduction study had a NOAEL of 1.9 mg/kg/day or NOAEC of 25 ppm is the basis for the chronic assessment. The NOAEL for the parent was based on “skin ulceration due to the paresthesia (skin numbness, tingling and itching), which causes the rats to continuously scratch themselves.” The NOAEL for the offspring was based on what the study review described as tremors and “slight body weight decrease.” Frank reproductive effects were not observed in the 2-generation rat reproduction study, but the ecological risk assessment considered the observed effects as “relevant to reproduction.”

A nose-only inhalation exposure study submitted for product reregistration of tau-fluvalinate and reviewed by the Agency found a LOAEC for systemic effects of 20 mg/m³ based on increased glucose levels and decreased body temperature, rearing and forelimb grip strength in females in addition to soiled fur appearance. The ‘no observed adverse effect concentration’ (NOAEC) could not be established for the study. No portal of entry effects were observed (MRID 49660601).

The 2010 new use assessment for **tefluthrin** used a body weight adjusted mammalian LD₅₀ of >102 mg/kg-bw for the rat. Therefore, while RQ’s calculated with this value exceed the acute LOC, the potential for actual acute risk is uncertain. Chronic risk quotients exceeded the LOC in this assessment, and were based on a reproduction study in which reduced weight gain in rat pups was observed. A 2016 assessment for use on corn also has RQ’s above the chronic LOC, based on the same reproduction study.

Tetramethrin is practically non-toxic to mammals on an acute basis, with an oral LD₅₀ >5000 mg/kg-bw. The chronic NOAEL for tetramethrin is 25 mg/kg bw/day, based on weight reduction in second generation pups at 120 mg/kg bw/day. RQ’s were not calculated in the 2010 RED, which in addition to the low toxicity, indicated that exposure was also likely to be low from “localized and fragmented use” patterns (aerosol cans, directed sprays and foggers) which “do not allow exposure to be quantified with standard models.”

Mammal Summary

All of the PWG pyrethroids have at least one acute RQ for small mammals calculated with maximum estimated residues that exceeds the non-listed acute LOC. The magnitude of the acute RQ’s is generally low for agricultural uses, and some would not exceed the LOC if calculated with mean estimated residues. Higher acute RQ’s were associated with higher applications to outdoor non-agricultural use sites, such as on airport runways (cyfluthrin) and ant mounds (deltamethrin). All eight of the PWG pyrethroids also had at least one chronic RQ for small mammals which exceeded the LOC. Similar to acute risk, the highest chronic RQ’s were associated with non-agricultural uses, with the highest RQ from the permethrin ESA assessment. There have not been any acute or chronic LOC exceedances for pyrethrins.

Only one of the 10 pyrethroids that are non-PWG pyrethroids has had at least one acute RQ calculated with maximum estimated residues that exceeded the non-listed LOC – tefluthrin. Tefluthrin is highly toxic to mammals, and a maximum acute RQ of over 16 for small mammals was calculated with maximum estimated residues. The other nine non-PWG pyrethroids either did not have RQ’s which exceeded the acute LOC (the closest was tau-fluvalinate, which had an acute RQ of <0.5, the acute non-listed LOC), or did not have RQ’s calculated because they were not toxic or were not likely to lead to significant exposure.

Only two of the 10 pyrethroids that are non-PWG pyrethroids has had at least one chronic RQ calculated with maximum estimated residues which exceeds the LOC, tau-fluvalinate and tefluthrin. Tau-fluvalinate had RQ's as high as 74, and tefluthrin as high as 159. The RQ's for these two chemicals were not based on frank reproductive effects but systemic effects observed in the rat reproduction studies (tremors and weight reduction, respectively).

Plant Taxa Risk

The Agency's previous pyrethroid risk assessments indicate that pyrethroids do not pose a risk to terrestrial and aquatic plants. Risk quotients (RQ's) for non-target terrestrial, aquatic/semi-aquatic plants could not be calculated for many of the pyrethroids due to a lack of toxicity data. Despite the lack of plant toxicity data, plant risk is not anticipated based on the neural toxic mode of action and the lack of studies demonstrating adverse effects to plants. In addition, certain pyrethroids do not have uses that will result in plant exposure. Therefore, it is unlikely that pyrethroids pose a risk of concern to terrestrial and aquatic/semi-aquatic plants.

As part of registration review, plant toxicity data were required for several pyrethroids in their chemical specific registration review data call-ins (DCIs).

The Agency's Levels of Concern (LOC) for terrestrial and aquatic plants are in Table 18 below:

Table 18. Agency Levels of Concern (LOC) for Terrestrial and Aquatic Plants

Terrestrial and Aquatic Plant Levels of Concern		
Risk Presumption	RQ	LOC
Acute Risk	EEC/EC ₂₅	1.0
Acute Endangered Species	EEC/EC ₀₅ or NOEC	1.0

Table 19 is a summary of plant RQ's that were calculated in support of the most recent previously completed pyrethroid chemical specific risk assessments.

Table 19. Aquatic and Terrestrial Plant Risk Quotients Calculated in Previous Risk Assessments

Active Ingredient	Aquatic/semi-aquatic Plant RQ's	Terrestrial Plant RQ's
Cyhalothrins (gamma, lambda)	-Non-vascular: ≤ 0.01 -Vascular: Not calculated (2009)	-Risks to non-target terrestrial and semi-aquatic plants could not be evaluated due to the lack of toxicity data; however, based on lambda-cyhalothrin's neural toxic mode of action, the lack of studies demonstrating adverse effects of lambda-cyhalothrin or any other pyrethroid to plants, and the fact that no incident reports have reliably linked lambda-cyhalothrin to phytotoxic effects despite being applied on or near agricultural plants, it appears unlikely that it poses a phytotoxic concern. (2010)

Active Ingredient	Aquatic/semi-aquatic Plant RQ's	Terrestrial Plant RQ's
Deltamethrin*	-Exposure from runoff and drift <0.01-<24.73 (2013 ESA) -Acute, vascular: <0.01-<0.05 -Acute, non-vascular: <0.01 (2014)	-Exposure from runoff and drift <0.01-<3.53 (2013 ESA) -Not calculated; the 2013 ESA assessment indicated no exceedance of LOC's up to approximately 0.1 lb ai/A as a single application rate. The mosquito adulticide application rate is about 100X lower, therefore, no further evaluation of risks to terrestrial plants was conducted for the 2014 assessment. (2014)
Etofenprox	-Aquatic, acute, vascular and non-vascular: ≤0.5 (2008)	-Not calculated; endpoints for terrestrial monocots and dicots were non-definitive, thus not possible to derive RQ's. Risk of phytotoxicity is considered to be lower than the Agency's concern levels. Although there is uncertainty associated with the non-definitive NOAEC value, the actual NOAEC value would have to be 143 times lower to result in an exceedance of the Agency's listed species LOC for terrestrial plants. (2008)
Prallethrin	-Non-Listed Aquatic, non-vascular and vascular: Not calculated -Listed aquatic vascular <0.01 – 0.15 (listed vascular) -Listed non-vascular- not calculated (2014)	-Monocots: 0.30 -Dicots: 0.30 (2014)

*Indicates PWG chemicals for which plant RQ's have been calculated in the 2016 assessment

As mentioned above, RQ's for non-target terrestrial, aquatic/semi-aquatic plants were not calculated for many of the pyrethroids due to the lack of toxicity data. Table 20 indicates pyrethroids for which plant RQ's were not previously calculated with brief explanations detailing the reasoning for not calculating RQ's.

Table 20. Aquatic and Terrestrial Plant Risk Quotients Not Calculated in Previous Risk Assessments

Active Ingredient	Rationale for Why RQ's Were Not Previously Calculated
Bifenthrin	Aquatic and terrestrial plant toxicity data were not available at the time of previous assessments. However, prior assessments indicate that plant risks are unlikely due to the chemical's mode of action as a neural toxin which suggests that direct toxicity to plants should not be an issue of concern. (2010)
Cyfluthrins*	Aquatic and terrestrial plant RQ's were not calculated in previous risk assessments and plant data were not required due to the results of previous phytotoxicity

Active Ingredient	Rationale for Why RQ's Were Not Previously Calculated
	testing with a pyrethroid surrogate, cypermethrin, which showed no evidence of phytotoxicity. Therefore, it's assumed that there is little risk aquatic and terrestrial plants. (2007)
Cypermethrin* (ANSI, -alpha, -zeta)	Phytotoxic effects are not expected due to the neural toxic mode of action. In addition, based on the lack of studies demonstrating adverse effects of zeta-cypermethrin or any other pyrethroid to plants, and the fact that no incident reports have reliably linked zeta-cypermethrin phytotoxic effects, it is not expected to pose a risk to plant taxa. (2011)
Cyphenothrin	Cyphenothrin is registered only for indoor uses, as a result there's no exposure pathway for plants, and an assessment was not required. (2013)
d-Phenothrin	Aquatic and terrestrial plant toxicity data were not available and considered a data gap, however, d-phenothrin exposure is not likely to result in adverse effects to terrestrial plant species. Seven minor incidents (details unknown) regarding damage to plants from exposure to d-phenothrin have been reported to the EPA. (2012)
Esfenvalerate*	Aquatic and terrestrial plant toxicity data were not available, however, based on studies available in the ECOTOX database, effects on terrestrial plants are expected to be unlikely. Losses of aquatic vascular and non-vascular plants are not expected for current label rates. (2008 ESA)
Fenpropathrin*	Aquatic and terrestrial plant toxicity data were not available. However, two terrestrial plant studies have been submitted to the agency and are under review. Incident reports suggest that there may be toxicity to plants exposed to fenpropathrin. (2013)
Flumethrin	Flumethrin is registered only for use in pet collars, as a result there is no exposure pathway for plants, and data submission and assessment were not required. (2016)
Imiprothrin	Based on the neural toxic mode of action, phytotoxic effects are not expected. In addition, imiprothrin is registered for indoor use only, as a result there's exposure pathway for plants, and data submission and an assessment was not required. (2006)
Momfluorothrin	Based on available data, and current label restrictions, exposure that would exceed the agency's LOC is unlikely, and further assessment was not required. (2014)
Permethrin*	Permethrin has a neural toxic mode of action, and no studies demonstrating significant adverse effects of permethrin to any vascular aquatic or terrestrial plant have been identified in the open literature, and further assessment was not required. (2008)
Pyrethrins	It is unlikely that pyrethrins pose a phytotoxic concern based on the mode of action on the sodium channels in insects, which do not exist in plant. Risks to terrestrial plants are not expected given the low potential and relatively low sensitivity of plants to similar active ingredients, as a result, no further assessment was required. (2015)
Tau-fluvalinate	Studies on two degradates of tau-fluvalinate indicate low risk to nonvascular aquatic plants, additionally, efficacy data in the open literature indicates a probably low risk to both terrestrial and nonvascular aquatic plants, no further assessment was required at the time of the RED (2005). Terrestrial and aquatic

Active Ingredient	Rationale for Why RQ's Were Not Previously Calculated
	plant studies were submitted for registration review, and preliminarily, the studies indicate that tau fluvalinate does not pose a risk to terrestrial or aquatic plants.
Tefluthrin	Considering use patterns and physical/chemical properties of tefluthrin, exposure is expected to be minimal to plant. Plant data were required in the registration review DCI, and preliminarily it appears that tefluthrin does not pose a risk to terrestrial and aquatic plants.
Tetramethrin	There is a low likelihood of exposure to non-target plants, because outdoor applications are limited to spot treatments, as a result, no further data was required at the time of the RED. (2010)

*Indicates PWG chemicals for which plant RQ's have been calculated in the 2016 assessment

Pollinator Risk

As a group, the pyrethroids are highly to very highly acutely toxic to honeybees (*Apis mellifera*). However, the Agency lacks most bee data necessary to assess risks to pollinators. When initially scoping the registration review for most pyrethroids, EPA did not identify the need for any additional studies to evaluate potential effects on pollinators. Since the issuance of the June 2014 Guidance for Assessing Pesticide Risks to Bees⁵ EPA has begun to require these data where applicable. EPA is currently determining whether additional pollinator data are needed for active ingredients in registration review whose dockets opened prior to June 2014, which would include most of the pyrethroids. For those active ingredients where EPA determines that additional pollinator exposure and effects data are necessary to make a final registration review decision, EPA intends to issue DCI's to obtain these data, and the pyrethroids are a priority for this effort. The pollinator studies that could be required are included in Table 21 below. The Agency will require the data it believes are needed to help inform the pollinator risk assessment.

Table 21. Potential Pollinator Data Requirements for the Pyrethroids

Guideline #	Study
850.3020*	Acute contact toxicity study with adult honey bees
850.3030*	Honey bee toxicity of residues on foliage
850.3040**	Field testing for pollinators
Non-Guideline* (OECD 213)	Honey bee adult acute oral toxicity
Non-Guideline* (OECD 237)	Honey bee larvae acute oral toxicity
Non-Guideline*	Honey bee adult chronic oral toxicity
Non-Guideline*	Honey bee larvae chronic oral toxicity
Non-Guideline**	Residues in pollen and nectar/field residue analysis
Non-Guideline** (OECD 75)	Semi-field testing for pollinators (tunnel or colony feeding studies)

⁵ https://www.epa.gov/sites/production/files/2014-06/documents/pollinator_risk_assessment_guidance_06_19_14.pdf

*Tier 1 (Laboratory-based studies)

**Tier 2 and 3 (Semi-field and full field colony-level studies) The need for a higher tier test for pollinators will be determined based upon lower-tiered tests and/or other lines of data and the need for a refined pollinator risk assessment.

While the Agency does not have a full complement of bee data for any pyrethroid, the Agency does have several acute contact and acute oral studies. A discussion of the known effects to bees based upon this data follows below. The proposed LOC for bees is 0.4 (USEPA, 2012). In addition, acute bee data was called in and submitted for registration review for some of the pyrethroids. This data appears to be consistent with previous toxicity tests.

Bifenthrin is very highly toxic to honeybees, though risk was not assessed in the 2007 assessment. The one bee study available at the time, acute contact study on honeybees, had an LD₅₀ of 0.015 µg/bee. In addition, risk to terrestrial invertebrates was evaluated in the 2012 bifenthrin San Francisco Bay California ESA assessment, and the honey bee acute RQ ranged from 6.3 (residential lawns) to as high as 811.8, for ornamental trees.

Risk to honeybees from **cyfluthrins** was presumed in the 2004 and 2006 assessments. Cyfluthrins is very highly toxic to honeybees on an acute contact basis, with an LD₅₀ of 0.03 µg/bee. A 10-day residual toxicity study on a formulated cyfluthrin product had an EC50 of 0.045 µg/bee and was also highly toxic. In the 2013 California endangered species ESA assessment, RQ's for terrestrial invertebrates ranged from 9.3 for beta-cyfluthrin on wheat to 822 for cyfluthrin on airport landing fields.

Lambda cyhalothrin data on the technical chemical gave a 48-hour contact LD₅₀ of 0.038 µg ai/bee and a 48-hour oral LD₅₀ of 0.909 µg ai/bee. Data on a formulated product gave a 48-hour contact LD₅₀ of 0.098 µg ai/bee and a 48-hour oral LD₅₀ of 0.483 µg ai/bee. Both are highly toxic to honeybees. A residue study on a formulated product gave an LT50 between 4 and 12 hours at the 0.013 lbs a.i./acre application rate and 23 hours at 0.031 lbs ai/acre rate, which indicates high toxicity. In a study where lambda-cyhalothrin was applied at rates of 7.5 g a.i./hectare and 15 g a.i./hectare to winter wheat with a sprayed sucrose solution, honeybee foraging was inhibited for up to three days. There was no significant increase in mortality at these treatment levels when compared to controls. **Gamma cyhalothrin** studies also indicate that this chemical is highly toxic to bees on a contact basis. The acute contact study gave an LD₅₀ value was 0.0061 µg a.i./bee (technical). Sublethal effects (lethargy and live animals on their backs) were observed in all treatment groups. In a contact test, honey bees were exposed to a 14.7% formulation for 48 hours, giving an LD₅₀ of 4.4 ng a.i./bee for gamma-cyhalothrin. Sublethal effects (lethargy and/or live animals on their backs) were observed in all treatment groups. The acute oral honeybee study submitted was invalid because measurements of actual concentrations were not conducted, however in an acute oral study with a gamma-cyhalothrin formulation in 48 hours, mortality ranged from 10 to 100%, and the LD₅₀ of 0.185 µg a.i./bee for gamma-cyhalothrin. A residue on foliage study with gamma-cyhalothrin formulation had no bee mortality in the control and all treatment groups and no signs of toxicity were observed during the study.

Risk to honeybees was not addressed in the **cypermethrin** RED. Risk to bees was not assessed in the **alpha cypermethrin** 2012 assessment, but it is highly toxic both on a contact (LD₅₀ = 0.033 µg a.i./bee) and an oral basis (LD₅₀ = 0.172 µg a.i./bee). Two supplemental field studies suggest that there is an increase in bee mortality following exposure in a field or semi-field setting. **Zeta-cypermethrin** is highly

toxic on both a contact ($LD_{50} = 0.023 \mu\text{g a.i./bee}$) and an oral basis ($LD_{50} = 0.172 \mu\text{g a.i./bee}$), and risk was presumed in the 2006 new use assessment.

The **cyphenothrin** problem formulation states that "(t)here are no data available on the toxicity of cyphenothrin to honey bees, although as an insecticide, adverse effects could be expected to occur." Currently there are limited outdoor uses of cyphenothrin.

For **deltamethrin**, risk to bees was assessed in the 2014 risk assessment. The acute contact RQ was 2.8, which exceeds the acute risk LOC of 0.4. Deltamethrin is very highly toxic to bees, with an LD_{50} of 1.5 ng/bee. In a foliage residue study conducted with a deltamethrin formulation, 100% mortality occurred in honey bees exposed to direct contact and significant adverse effects (78% mortality) still occurred when bees were exposed to foliage 34 hours after treatment. In another foliage residual test, the RT25 at 0.02 lbs a.i./A was estimated to be somewhere between 2 and 8 hours after treatment (MRID 42773902). In the 2013 California ESA assessment, risks to terrestrial invertebrates ranged from an RQ of 9.6 on right-of-ways to 20,600 for ornamental plant ant mound treatment. RQ's were over 1000 for residential and barnyard outdoor premises, sod farms, lawn and turf, and ornamental plants.

Although the submitted deltamethrin bee studies have not yet formally been reviewed, acute oral and contact honeybee studies seem to indicate that deltamethrin is very highly toxic to terrestrial invertebrates. The reported 72-hour LD_{50} values for oral and contact exposure were 0.19 and 0.11 $\mu\text{g a.i./bee}$, respectively.

In the **d-phenothrin** RED, the available studies suggest that the concern for acute toxicity to non-target insects is high ($LD_{50} = 0.067\text{mg a.i.}$) when they are exposed directly to D-phenothrin. Risks to bees was not assessed in the 2012 assessment on the misting system use.

The risks of **esfenvalerate** to bees has not been assessed. However esfenvalerate is highly toxic to honey bees on an acute contact basis, with a 48-hour LD_{50} of 0.017 $\mu\text{g/bee}$. Risks to terrestrial invertebrates were assessed in the 2008 esfenvalerate California ESA assessment, where small insect RQ's ranged from 5.9 for field corn to 57.7 for general outdoor surfaces.

There is no data to assess risks to bees for **etofenprox**; risk to bees from **etofenprox** was not assessed in 2008 or 2010 assessments.

Risk to bees from **fenpropathrin** was presumed in the 2008 new use assessment. In the 2013 new use assessment on multiple crops, no acute contact study was available, but data for other pyrethroids was used to calculate an LD_{50} ; no RQ's were calculated.

Risks to honeybees from **flumethrin** was not calculated because there is only a pet collar use. There is no honey bee data available to assess risks to bees. In a 2016 combined registration review Problem Formulation/Risk Assessment, no data is identified as a data gap to be called in for registration review, including for honeybees.

Imiprothrin is highly toxic to honeybees, but no RQ's were calculated in the most recent assessments because there are limited outdoor uses. The 48-hour LD_{50} is 0.52 $\mu\text{g a.i./bee}$.

In the **momfluorothrin** 2012 registration assessment, the acute contact RQ was 1.2 and the acute oral RQ was 0.57 based on the acute contact LD₅₀ of 0.2 µg a.i./bee, and the oral acute LD₅₀ of 5.08 µg/bee. However, momfluorothrin is intended to target insects directly, not as a prophylactic treatment of entire areas, upon which this risk estimation is based.

In the **permethrin** RED, risk to bees was not assessed, but it was noted that permethrin is highly toxic on both a contact and an oral basis (contact LD₅₀ = 0.13 µg /bee; oral LD₅₀ = 0.024 µg /bee). Permethrin was assessed in a 2010 ESA assessment. Risk to small terrestrial invertebrates ranged from 1.6 for mosquito adulticide control to 7400 for residential turf and ornamentals.

In a 2014 new use assessment for **prallethrin**, acute RQ's for dietary-based exposure of adult and larval bees could not be calculated due to the lack of dietary-based toxicity data. There is an acute contact study, with a LC₅₀ of 0.028 µg a.i./bee. There is also a foliage residue study on alfalfa, that gave a 24 hour NOAEC of 0.005 lb/a.i./acre for on formulation (2.45), and ≥0.0008 lb a.i./A for a fogging concentrate formulation. An acute RQ of 0.02 for contact exposure of adult bees was calculated, which is below the proposed LOC for bees of 0.4.

Bees were not assessed in **pyrethrins** RED, but risk was expected to honeybees due to toxicity from drift resulting from aerial applications. Pyrethrins are highly toxic to honeybees, with a contact LC₅₀ = 0.022 µg a.i./bee and an oral LD₅₀ is 0.15 µg a.i./bee. The risks to bees were not assessed in 2015 new use on mosquito coils.

The RED chapter indicated that **tau-fluvalinate** is highly toxic to honey bees. An estimate of potential exposure exceeded the LD₅₀ and so the assessment concluded "it is likely that there is significant risk to terrestrial insects in the direct treatment area." It noted also that "tau-fluvalinate is also used in apiary strips to control Varroa mite parasite of domestic honeybees in hives." The ecological risk assessment for the RED concluded that "dried residues are not toxic to honey bees." An acceptable residual toxicity test for honey bees concluded that "applications at the tested levels pose minimal hazard to honey bees when they are not actively foraging."

There is no data to assess the risks to honeybees from exposure to **tefluthrin**, and so risks were not assessed in the 2010 new uses assessment on beet treated seed or the 2016 new use on corn.

Tetramethrin is highly toxic to honeybees, with an LD₅₀ = 0.155 µg/bee. A residue on foliage study showed a residue decrease to a negligible level at 3 hours post treatment. Mortality was seen at 3, 8, and 24 hours post treatment. No RQ's for bees were calculated in the RED.

Synergism

Pyrethrins and other early generation pyrethroids such as allethrin and permethrin are often formulated with a synergist which increases the efficacy of the pyrethroids. These compounds act on mixed function oxidases to decrease the rate at which the pyrethroid is metabolized in the body and effectively increase the duration of exposure. This mode of action is most effective on easily metabolized compounds such as the pyrethrins and may have little effect on those that are more persistent such as cyfluthrin.

There are currently three pyrethroid synergists registered for use in the United States, MGK-264, MGK-326, and piperonyl butoxide, commonly known as PBO. Two others synergists are no longer registered, piprotal and sulfoxide) in the United States. Of the three registered, piperonyl butoxide dominates the market. MGK-326 has some limited indoor uses, and MGK-264 has indoor uses and limited outdoor uses for bees and wasps on buildings. In most cases, PBO is co-formulated in pyrethroid pesticide products, though there are also products containing only PBO that can be tank-mixed before application.

The toxicity endpoints used in various constituent ecological risk assessment supporting registration review of the pyrethroids were mainly from studies with each single active ingredient alone, and did not incorporate the potential toxicity enhancement from the co-application of PBO. To estimate the toxicity enhancement to non-target organisms, toxicity enhancement factors are being developed. These values should be finalized during Registration Review of PBO in 2017; a factor of synergism of 1.7 has been applied to the aquatic risk assessment for invertebrates in Part III of the ecological risk assessment for agricultural uses. This factor of synergism is based on PBO:pyrethrins synergism data submitted to the Agency for the freshwater amphipod, *Hyalella azteca*, was applied in combination with the predicted additive effects of PBO when assumed to be present at sublethal concentrations. The effects of synergists on indoor and outdoor non-agricultural uses were not assessed at this time. Relative to more metabolically stable synthetic pyrethroids, the synergism factor for pyrethrins is expected to be a conservative estimate. Because risk thresholds for most uses of the pyrethroids are already exceeded, consideration of synergists increases the level of exceedance but does not appear to trigger any additional exceedances. No estimates for vertebrates are available at this time, though a PBO and pyrethrins synergism study with fish has been requested and should be available later this year.

PBO and the pyrethroids have different fate profiles and consequently the relative concentrations of these two compounds will change in the environment relative to the original ratio in the formulation with time and distance from the site of application. PBO is somewhat more persistent and mobile than the majority of the pyrethroids, so it will move farther and last longer in the environment. The Agency is currently reviewing additional synergy data for pyrethrins with PBO, and is expecting to receive other data on representative second generation pyrethroids. The Agency will analyze these data as they are received.

Conclusion and Next Steps

EPA believes that the current assessment completed for eight PWG pyrethroid active ingredients (bifenthrin, cyfluthrins, cyhalothrins, cypermethrins, deltamethrin, esfenvalerate, fenpropathrin, permethrin) and the pyrethrins, in combination with the conclusions from previous assessments for these chemicals and for those active ingredients that were not quantitatively assessed at this time, serve as a basis for risk management, mitigation, and regulatory decisions for all of the pyrethroids currently undergoing registration review.

- The pyrethroids have many uses across agricultural, residential, commercial, indoor and outdoor sites, and were grouped into broad categories to compare the potential exposure for those active ingredients that were not quantitatively assessed in the current assessment.
- Risk conclusions from previous ecological risk assessments were also discussed from multiple sources, including the Registration Eligibility Decisions (REDs), Endangered Species Assessments, new use assessments described in the problem formulations completed for registration review, and new use assessments completed since the problem formulations.
- Where possible, the preliminary results of new data conducted for aquatic organisms submitted for registration review, as well as data submitted for other taxa, including mammals, birds, and pollinators, was discussed. While not all of the new data has been reviewed in full, preliminary reviews and completed DERs of studies submitted for aquatic taxa, birds, mammals, and pollinators are consistent with the toxicity profile seen in previous studies.
- The toxicity of pyrethroids to aquatic organisms is well established and drives the risk conclusions for these chemicals. The aquatic risk assessment completed for the nine PWG active ingredients came to similar conclusions as past assessments with regard to aquatic taxa.
- While risks have been found for some chemicals to birds and mammals in previous assessments, the overwhelming pattern through multiple assessments is consistent, clear risk to aquatic organisms. Mitigation to address risks to aquatic organisms will also benefit these other taxa, to the extent that there is any risk.
- Honey bee data will be called in for the pyrethroids to inform a risk assessment on pollinators. Given the available data and a preliminary assessment of that data in the current assessment, risk to bees is well understood and the pyrethroids are a priority for calling in this data.

The pyrethroids that were not quantitatively assessed at this time are represented by the nine quantitatively assessed active ingredients with regard to toxicity, use pattern, and exposure. Quantitatively assessing the non-PWG chemicals again would give similar results to previous assessments, just as it has for the nine PWG chemicals. The Agency intends to issue interim decision documents for the pyrethroids and, as necessary, to propose mitigation as a class for these chemicals. The active ingredients that were not quantitatively assessed in the EFED streamlined assessment will not be quantitatively assessed at this time. However, all of the pyrethroids will be revisited at a later date to assess risks to endangered species and risks to pollinators.

Appendix A. Bibliography

The following documents are referenced in this document. Detailed discussion of the risks to aquatic organisms, mammals, birds, plants and pollinators from exposure to pyrethroids are included in the following risk assessment and problem formulation documents, located in the docket at:

<http://www.regulations.gov>.

By Chemical

Bifenthrin

- Bifenthrin EFED Science Chapter for the Section 3 and IR-4 New Uses on Mayhew, Vegetable Roots, Except Sugar Beets, Peanut, Soybean, and Fruiting Vegetables Subgroup B. September 27, 2007.
- Revised EFED Registration Review Problem Formulation for Bifenthrin. December 22, 2010.
- Risks of Bifenthrin Use to Federally Threatened Bay Checkerspot Butterfly (*Euphydryas editha bayensis*), Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*), California Tiger Salamander (*Ambystoma californiense*), Central California Distinct Population Segment, and Delta Smelt (*Hypomesus transpacificus*), And the Federally Endangered California Clapper Rail (*Rallus longirostris obsoletus*), California Freshwater Shrimp (*Syncaris pacifica*), California Tiger Salamander (*Ambystoma californiense*) Sonoma County Distinct Population Segment and Santa Barbara County Distinct Population Segment, San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*), and Tidewater Goby (*Eucyclogobius Newberry*). December 27, 2012.

Cyfluthrins

- Cyfluthrin Environmental Risk Assessment for the Registration of the New Uses of Cyfluthrin on Tree Nuts, Grapes and Peanuts, Wheat, Leafy Vegetables, Fruiting Vegetables, Cucurbits, Leafy Brassica, Pome Fruit, Stone Fruit; in Addition to IR-4 Tolerance Petition for the Use of Cyfluthrin on Tuberous and Corm Vegetables, Turnip Greens, Dried Shelled Peas and Beans (except soybeans), Grass Hay, and Grass Forage. July 13, 2004.
- Environmental Risk Assessment for the New Use Registration of Cyfluthrin on Tobacco. February 27, 2006.
- EFED Registration Review Problem Formulation for Cyfluthrin and Beta-cyfluthrin. July 29, 2010
- Risks of Cyfluthrin and Beta-Cyfluthrin Use To Federally Threatened Bay Checkerspot Butterfly (*Euphydryas editha bayensis*), Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*), California Tiger Salamander (*Ambystoma californiense*), Central California Distinct Population Segment, and Delta Smelt (*Hypomesus transpacificus*), and the Federally Endangered California Clapper Rail (*Rallus longirostris obsoletus*), California Freshwater Shrimp (*Syncaris pacificus*), California Tiger Salamander (*Ambystoma californiense*) Sonoma County Distinct Population Segment and Santa Barbara County Distinct Population Segment, San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*), and Tidewater Goby (*Eucyclogobius newberryi*). March 28, 2013

Cyhalothrins

- Section 3 request for new uses of lambda cyhalothrin (P.C. Code: 128897) on peas and beans, fruiting vegetables, canola, sugarcane, sorghum, wheat, wheat hay and other small grains, peanut hay, pome fruit, stone fruit, tree nuts, termite barrier, tobacco, non-cropland and trees (conifer and deciduous trees) (DP Barcode D262918, D262919, D279087, D279088). June 12, 2002.
- Cyhalothrins Environmental Fate and Ecological Risk Assessment for Section 3 Registration of Lambda-cyhalothrin, an Insecticide for New Uses on Cereal Grains, Cucurbit Vegetables, Grass Forage, Fodder and Hay, Wild Rice and Tuberous and Corm Vegetables. December 29, 2006.
- EFED Registration Review Problem Formulation for Lambda-cyhalothrin and Gamma-cyhalothrin. November 22, 2010.

Cypermethrins

- Reregistration Eligibility Decision (RED) for Cypermethrin. October 25, 2005, Revised January 14, 2008 including the EFED Chapter Addendum dated June 9, 2006
- Revised Environmental Fate and Ecological Risk Assessment for Section 3 Registration of Zeta-cypermethrin; New Uses Pesticide Registration: New Uses on Cilantro, Head and Stem Brassica Vegetables, Leafy Vegetables (except Brassica), Sunflowers, Grass Forage Fodder, Hay Group, Canola, Grapeseed, Barley, Grapes, Tree Nut Group (almond, pecan), Berries, Peanuts, Root and Tuber Vegetables, Cucurbit Vegetable Group, Non-Grass Animal Feed (Forage Fodder, Straw and Hay), Turf (for use on residential lawns, home perimeter, ornamental and flower gardens), Pome Fruits, Stone Fruits, and Termiticide Uses. August 3, 2006.
- Registration Review: Preliminary Problem Formulation for Environmental Fate and Ecological Risk, Endangered Species, and Drinking Water Assessments for Cypermethrin and Zeta-Cypermethrin (Case No. 2130). March 1, 2012.
- Environmental Fate and Ecological Risk Assessment for the Section 3 New Chemical Registration of Alpha-Cypermethrin. September 19, 2012
- Environmental Fate and Ecological Risk Assessment for Section 3 of New Uses of Zeta-cypermethrin to control Darkling Beetles (Lesser Mealworm) in Poultry Litter in Chicken Broiler and Turkey Growout Houses. January 3, 2013.

Cyphenothrin

- Registration Review –Preliminary Problem Formulation for Ecological Risk and Environmental Fate, Endangered Species, and Drinking Water Assessments for Cyphenothrin. December 15, 2009.
- Revised memo: Need for Environmental Risk Assessment of Sergeant's Fipronil and Cyphenothrin BOV Spray for Dogs. May 16, 2013.

Deltamethrin

- EFED Revised Registration Review Problem Formulation for Deltamethrin. March 23, 2010.
- Risks of Deltamethrin Use to Federally Threatened Bay Checkerspot Butterfly (*Euphydryas editha bayensis*), Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*), California Tiger Salamander (*Ambystoma californiense*), Central California Distinct Population Segment, and Delta Smelt (*Hypomesus transpacificus*), And the Federally Endangered California Clapper Rail (*Rallus longirostris obsoletus*), California Freshwater

Shrimp (*Syncaris pacificus*), California Tiger Salamander (*Ambystoma californiense*) Sonoma County Distinct Population Segment and Santa Barbara County Distinct Population Segment, San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*), and Tidewater Goby (*Eucyclogobius newberryi*). March 28, 2013

- Petition for the New Use of Deltamethrin as a Mosquito Adulticide in the Product BES0668 Insecticide (PC Code 097805; DP Barcode D417551). December 3, 2014.

d-Phenothrin

- Reregistration Eligibility Decision (RED) for d-Phenothrin. September 25, 2008.
- Registration Review: Preliminary Problem Formulation for Environmental Fate and Ecological Risk, Endangered Species, and Drinking Water Assessments for d-Phenothrin (Case 0426). December 8, 2011.
- Environmental Fate and Ecological Risk Assessment for the Proposed New Use of d-Phenothrin in Outdoor Residential Misting Systems. November 21, 2012.
- Section 3 New Use D-Phenothrin: Product Multicide Fogging Concentrate 2922. February 20, 2013.

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- Risks of Esfenvalerate Use to Federally Threatened California Red-Legged Frog. February 19, 2008
- Registration Review: Preliminary Problem Formulation for Ecological Risk, Environmental Fate, Endangered Species, and Drinking Water Assessment for Esfenvalerate. June 21, 2010.

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- Registration Review – Preliminary Problem Formulation for the Ecological Risk Assessment of Etofenprox. August 16, 2007.
- Environmental Fate and Ecological Risk Assessment for Etofenprox New Uses on Rice and for Vector Control. June 30, 2008
- Etofenprox New Use for Mound-Building Ant Control and Label Amendment for Outdoor Structural Use: Ecological Risk and Endangered Species Assessment. January 4, 2010.

Fenpropathrin

- EFED Section 3 Registration of Fenpropathrin (DANITOL 2.4 EC) Insecticide/Miticide for use on Bushberries, Caneberry Subgroup 13A, Olives, Currant, Peas, Fruiting Vegetables, Avocado, Stone Fruit, Tree Nuts, Pistachio, Tropical Fruits, Barley and IR-4 Registration for use on Stone Fruit, Tree Nuts, Avocado, Stone Fruit, and Pistachio. February 19, 2008
- EFED Registration Review Problem Formulation for Fenpropathrin. June 16, 2010.
- Environmental Fate and Ecological Risk Assessment for the Proposed New Uses of Fenpropathrin for Small Fruit Vine Climbing (Except Fuzzy Kiwifruit) Subgroup 13-07F, Citrus Group 10-10, Pome Fruit Group 11-10, Fruiting Vegetable Group 8-10, Berry Subgroup 13-07B, Low Growing Berry Subgroup 13-07G, and Barley. August 27, 2013.

Flumethrin

- Flumethrin Preliminary Problem Formulation and Ecological Risk Assessment and Effects Determination in Support of Registration Review. July 5, 2016.

Imiprothrin

- Environmental Fate and Ecological Risk Assessment for the New Use Section 3 Registration of Imiprothrin. April 21, 2006.
- Registration Review: Preliminary Problem Formulation for Environmental Fate, Ecological Risk, Endangered Species, and Drinking Water Exposure Assessments for Imiprothrin. September 13, 2011.

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- Effects Determination for Permethrin and the California Red-legged Frog, Bay Checkerspot Butterfly, California Clapper Rail, Salt Marsh Harvest Mouse, and San Francisco Garter Snake. October 20, 2008
- Risks of Permethrin Use to Federally Threatened Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*). September 30, 2010
- EFED Registration Review Preliminary Problem Formulation for Permethrin (PC Code 109701; Case No. 2510; DP Barcode D384703). June 20, 2011.

Prallethrin

- Registration Review: Preliminary Problem Formulation for Environmental Fate, Ecological Risk, Endangered Species, and Drinking Water Exposure Assessments for Prallethrin. April 17, 2010.
- Prallethrin: Revised Ecological Risk Assessment to Support Proposed New Use Over, Near, and Around Agricultural Areas. February 6, 2014.

Pyrethrins

- Reregistration Eligibility Decision (RED) for Pyrethrins. June 7, 2006.
- Environmental Fate and Ecological Risk Assessment Preliminary Problem Formulation in Support of Registration Review of Pyrethrins. November 30, 2011.
- Screening-Level Ecological Risk Assessment for Pyrethrins: Petition to Register the Product MGK Formula 3098 Formulated as Mosquito Repellent Coils. (PC Code 069001; DP Barcode D423973). June 18, 2015.

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- Registration Review – Preliminary Problem Formulation for the Ecological Risk and Drinking Water Exposure Assessments for Tau-Fluvalinate (PC Code 109302; DP Barcode 378274). December 15, 2010.
- Reregistration Eligibility Decision (RED) for Tau-fluvalinate. September 2005. and Around Agricultural Areas. February 6, 2014.

Tefluthrin

- Tefluthrin Sec. 3 and Registration Standard. December 18, 1987
- Environmental Fate and Ecological Risk Assessment for the Proposed New Use of Tefluthrin on Sugar Beets as a Seed Treatment. June 6, 2010.

- Registration Review: Preliminary Problem Formulation for Environmental Fate and Ecological Risk, Endangered Species, and Drinking Water Assessments for Tefluthrin. August 30, 2012.
- Tefluthrin use on Corn – Review of the Petition for Amendment to Product Labels: Force CS Insecticide (EPA Reg. No. 100-1253), and Force 3G Insecticide (EPA Reg No. 100-1075). March 2, 2016.

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- Reregistration Eligibility Decision (RED) for **Tetramethrin**. Revised April 16, 2010.
- Registration Review – Preliminary Problem Formulation for the Ecological Risk Assessment for Tetramethrin. December 5, 2010.

By Document Type

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- Reregistration Eligibility Decision (RED) for **Cypermethrin**. October 25, 2005, Revised January 14, 2008 including the EFED Chapter Addendum dated June 9, 2006
- Reregistration Eligibility Decision (RED) for **d-Phenothrin**. September 25, 2008.
- Reregistration Eligibility Decision (RED) for **Permethrin**. May 11, 2009.
- Reregistration Eligibility Decision (RED) for **Pyrethrins**. June 7, 2006.
- Reregistration Eligibility Decision (RED) for **Tau-fluvalinate**. September 2005.
- Reregistration Eligibility Decision (RED) for **Tetramethrin**. Revised April 16, 2010.

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- Environmental Fate and Ecological Risk Assessment for the Section 3 New Chemical Registration of **Alpha-Cypermethrin**. September 19, 2012
- Environmental Fate and Ecological Risk Assessment for the Section 3 New Chemical Registration of the Pyrethroid Insecticide **Momfluorothrin**. December 4, 2104.

New Use Assessments:

Bifenthrin

- Bifenthrin EFED Science Chapter for the Section 3 and IR-4 New Uses on Mayhew, Vegetable Roots, Except Sugar Beets, Peanut, Soybean, and Fruiting Vegetables Subgroup B. September 27, 2007

Cyfluthrins

- Cyfluthrin Environmental Risk Assessment for the Registration of the New Uses of Cyfluthrin on Tree Nuts, Grapes and Peanuts, Wheat, Leafy Vegetables, Fruiting Vegetables, Cucurbits, Leafy Brassica, Pome Fruit, Stone Fruit; in Addition to IR-4 Tolerance Petition for the Use of Cyfluthrin on Tuberous and Corm Vegetables, Turnip Greens, Dried Shelled Peas and Beans (except soybeans), Grass Hay, and Grass Forage. July 13, 2004.
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- Cyhalothrins Environmental Fate and Ecological Risk Assessment for Section 3 Registration of Lambda-cyhalothrin, an Insecticide for New Uses on Cereal Grains, Cucurbit Vegetables, Grass Forage, Fodder and Hay, Wild Rice and Tuberous and Corm Vegetables. December 29, 2006.

Cypermethrins

- Revised Environmental Fate and Ecological Risk Assessment for Section 3 Registration of Zeta-cypermethrin; New Uses Pesticide Registration: New Uses on Cilantro, Head and Stem

Brassica Vegetables, Leafy Vegetables (except Brassica), Sunflowers, Grass Forage Fodder, Hay Group, Canola, Grapeseed, Barley, Grapes, Tree Nut Group (almond, pecan), Berries, Peanuts, Root and Tuber Vegetables, Cucurbit Vegetable Group, Non-Grass Animal Feed (Forage Fodder, Straw and Hay), Turf (for use on residential lawns, home perimeter, ornamental and flower gardens), Pome Fruits, Stone Fruits, and Termiticide Uses. August 3, 2006.

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d-Phenothrin

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- Environmental Fate and Ecological Risk Assessment for Etofenprox New Uses on Rice and for Vector Control. June 30, 2008
- Etofenprox New Use for Mound-Building Ant Control and Label Amendment for Outdoor Structural Use: Ecological Risk and Endangered Species Assessment. January 4, 2010.

Fenpropathrin

- EFED Section 3 Registration of Fenpropathrin (DANITOL 2.4 EC) Insecticide/Miticide for use on Bushberries, Caneberry Subgroup 13A, Olives, Currant, Peas, Fruiting Vegetables, Avocado, Stone Fruit, Tree Nuts, Pistachio, Tropical Fruits, Barley and IR-4 Registration for use on Stone Fruit, Tree Nuts, Avocado, Stone Fruit, and Pistachio. February 19, 2008
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Imiprothrin

- Environmental Fate and Ecological Risk Assessment for the New Use Section 3 Registration of Imiprothrin. April 21, 2006.

Prallethrin

- Prallethrin: Revised Ecological Risk Assessment to Support Proposed New Use Over, Near, and Around Agricultural Areas. February 6, 2014.

Pyrethrins

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- Environmental Fate and Ecological Risk Assessment for the Proposed New Use of Tefluthrin on Sugar Beets as a Seed Treatment. June 6, 2010.
- Tefluthrin use on Corn – Review of the Petition for Amendment to Product Labels: Force CS Insecticide (EPA Reg. No. 100-1253), and Force 3G Insecticide (EPA Reg No. 100-1075). March 2, 2016.

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- Revised EFED Registration Review Problem Formulation for Bifenthrin. December 22, 2010.
- EFED Registration Review Problem Formulation for Cyfluthrin and Beta-cyfluthrin. July 29, 2010
- EFED Registration Review Problem Formulation for Lambda-cyhalothrin and Gamma-cyhalothrin. November 22, 2010.
- Registration Review –Preliminary Problem Formulation for Ecological Risk and Environmental Fate, Endangered Species, and Drinking Water Assessments for Cyphenothrin. December 15, 2009.
- Registration Review: Preliminary Problem Formulation for Environmental Fate and Ecological Risk, Endangered Species, and Drinking Water Assessments for Cypermethrin and Zeta-Cypermethrin (Case No. 2130). March 1, 2012.
- Registration Review: Preliminary Problem Formulation for Environmental Fate and Ecological Risk, Endangered Species, and Drinking Water Assessments for d-Phenothrin (Case 0426). December 8, 2011.
- EFED Revised Registration Review Problem Formulation for Deltamethrin. March 23, 2010.
- Registration Review: Preliminary Problem Formulation for Ecological Risk, Environmental Fate, Endangered Species, and Drinking Water Assessment for Esfenvalerate. June 21, 2010.
- Registration Review – Preliminary Problem Formulation for the Ecological Risk Assessment of Etofenprox. August 16, 2007.
- EFED Registration Review Problem Formulation for Fenpropathrin. June 16, 2010.
- Flumethrin Preliminary Problem Formulation and Ecological Risk Assessment and Effects Determination in Support of Registration Review. July 5, 2016.
- Registration Review: Preliminary Problem Formulation for Environmental Fate, Ecological Risk, Endangered Species, and Drinking Water Exposure Assessments for Imiprothrin. September 13, 2011.
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- Registration Review: Preliminary Problem Formulation for Environmental Fate, Ecological Risk, Endangered Species, and Drinking Water Exposure Assessments for Prallethrin. April 17, 2010.
- Environmental Fate and Ecological Risk Assessment Preliminary Problem Formulation in Support of Registration Review of Pyrethrins. November 30, 2011.
- Registration Review – Preliminary Problem Formulation for the Ecological Risk and Drinking Water Exposure Assessments for Tau-Fluvalinate (PC Code 109302; DP Barcode 378274). December 15, 2010.
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- Risks of **Bifenthrin** Use to Federally Threatened Bay Checkerspot Butterfly (*Euphydryas editha bayensis*), Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*), California Tiger Salamander (*Ambystoma californiense*), Central California Distinct Population Segment, and Delta Smelt (*Hypomesus transpacificus*), And the Federally Endangered California Clapper Rail (*Rallus longirostris obsoletus*), California Freshwater Shrimp (*Syncaris pacifica*), California Tiger Salamander (*Ambystoma californiense*) Sonoma County Distinct Population Segment and Santa Barbara County Distinct Population Segment, San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*), and Tidewater Goby (*Eucyclogobius newberryi*). December 27, 2012
- Risks of **Cyfluthrin** and **Beta-Cyfluthrin** Use To Federally Threatened Bay Checkerspot Butterfly (*Euphydryas editha bayensis*), Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*), California Tiger Salamander (*Ambystoma californiense*), Central California Distinct Population Segment, and Delta Smelt (*Hypomesus transpacificus*), and the Federally Endangered California Clapper Rail (*Rallus longirostris obsoletus*), California Freshwater Shrimp (*Syncaris pacificus*), California Tiger Salamander (*Ambystoma californiense*) Sonoma County Distinct Population Segment and Santa Barbara County Distinct Population Segment, San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*), and Tidewater Goby (*Eucyclogobius newberryi*). March 28, 2013
- Risks of **Deltamethrin** Use to Federally Threatened Bay Checkerspot Butterfly (*Euphydryas editha bayensis*), Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*), California Tiger Salamander (*Ambystoma californiense*), Central California Distinct Population Segment, and Delta Smelt (*Hypomesus transpacificus*), And the Federally Endangered California Clapper Rail (*Rallus longirostris obsoletus*), California Freshwater Shrimp (*Syncaris pacificus*), California Tiger Salamander (*Ambystoma californiense*) Sonoma County Distinct Population Segment and Santa Barbara County Distinct Population Segment, San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*), and Tidewater Goby (*Eucyclogobius newberryi*). March 28, 2013
- Risks of **Esfenvalerate** Use to Federally Threatened California Red-Legged Frog. February 19, 2008
- Effects Determination for **Permethrin** and the California Red-legged Frog, Bay Checkerspot Butterfly, California Clapper Rail, Salt Marsh Harvest Mouse, and San Francisco Garter Snake October 20, 2008

- Risks of **Permethrin** Use to Federally Threatened Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*) September 30, 2010

Appendix B. Risk Quotient Tables

Aquatic Taxa Risk Quotients

Active Ingredient	Freshwater Fish	Estuarine/Marine Fish	Freshwater Invertebrate	Estuarine/Marine Invertebrate
Bifenthrin*	Acute: 0.58-0.67 Chronic: 0.425-2.5 (2007) Acute: <0.01 – 0.09 Chronic: 0.01 – 3.50 (2012 ESA)	Acute: 0.00 Chronic: not calculated (2007) Acute: <0.01 Chronic: 0.01- 3.50 (2012 ESA)	Acute: 0.063 Chronic: 15.4-77 (2007) Acute: 0.07-7.37 Chronic: 0.22-82.35 (2012 ESA)	Acute: 25 Chronic: not calculated (2007) Acute: 0.03-3.53 Chronic: 0.19-70.00 (2012 ESA)
Cyfluthrins*	Acute: 1.5-39 Chronic:0.45-30 (2004) Acute: 0.37-33.8 Chronic: 1.7 -547.6 (2013 ESA)	Acute: <0.01-0.70 Chronic:0.10-12 (2004) Acute: 0.01 – 1.35 Chronic: 0.64-209.1 (2013 ESA)	Acute: 1.7- 107 Chronic: 1.3 - 61 (2004) Acute: 0.08 – 7.93 Chronic: 3-766.7 (2013 ESA)	Acute: 48- 1214 Chronic: 45-2130 (2004) Acute: 11.4-1045.5 Chronic: 128.6-32,857.1 (2013 ESA)
Cyhalothrins * (gamma)	See Cyhalothrins, lambda			
Cyhalothrins (lambda)	Acute: 0.50-1.07 Chronic: 0.26-0.97 (2002) Acute: 0.12 – 1.97 Chronic: 0.10- 2.87 (2006)	Acute: 0.13- 0.28 Chronic: 0.3-0.12 (2002) Acute:0.03- 0.51 Chronic: 0.01- 0.36 (2006)	Acute: 15.0-32.0 Chronic: 6.5-19.5 (2002) Acute: 3.57-59.14 Chronic:2.0-85.0 (2006)	Acute: 21.0-44.8 Chronic: 65-195 (2002) Acute: 5.0-82.8 Chronic: 20-850 (2006)
Cypermethrin* (ANSI)	Acute: 0.5-5.2 Chronic: 0.1-0.7 (2006)	Acute: 0.2-2.1 Chronic:0.1 -0.03 (2006)	Acute: 49.4-558.3 Chronic: 57.6-325.4 (2006)	Acute: 37-423 Chronic:44-246 (2006)
Cypermethrin-alpha*	Acute:0.02-0.28 Chronic: 0.03-0.21 (2012)	Acute: 0.04-0.65 Chronic:0.07-0.33 (2012)	Acute:11.11-172.22 Chronic:16.95-101.69 (2012)	Acute:8.42-130.53 Chronic: 12.80-76.82 (2012)
Cypermethrin- zeta*	Acute: 0.10-3.73 Chronic: 0.02-0.46 (2006)	Acute: 0.04-1.53 Chronic: <0.01-0.19 (2006)	Acute: 11.25-404.44 Chronic: 6.83-206.78 (2006)	Acute: 8.53-306.53 Chronic: 5.16-156.21 (2006)
Cyphenothrin	Not calculated (2009 PF, 2013)			
Deltamethrin*	Acute: 0.01-0.06 Chronic: 0.01-0.11 (2014) Acute: <0.01 – 0.34	Acute: 0.01-0.06 Chronic: <0.01-0.08 (2014) Acute: <0.01 – 0.34	Acute: 1.8-9.3 Chronic: >7.4->87.7 (2014)	Acute: 2.0-10.0 Chronic:0.26-3.1 (2014) Acute: 0.11-54.1

Active Ingredient	Freshwater Fish	Estuarine/Marine Fish	Freshwater Invertebrate	Estuarine/Marine Invertebrate
	Chronic: <0.01 – 11.8 (2013 ESA)	Chronic: <0.01 – 8.33 (2013 ESA)	Acute: 0.11 – 50.0 Chronic: >4.73 - >7690 (2013 ESA)	Chronic: 0.07- 274 (2013 ESA)
d-Phenothrin	Acute: 0.002 Chronic: not calculated (2012)	Acute: <0.001 Chronic: not calculated (2012)	Acute:0.02-0.07 Chronic: 0.11-0.55 (2008) Acute: 0.007 Chronic: not calculated (2012)	Acute: 3.20-13.00 Chronic: 19.61-99.61 (2008) Acute: 1.20 Chronic: not calculated (2012)
Esfenvalerate *	Acute: 0.24-92.33 Chronic: 0.02-20.17 (2008 ESA)	Not calculated (2008 ESA)	Acute:0.35-129.26 Chronic: 2.12 – 33.41 (2008 ESA)	Not calculated (2008 ESA)
Etofenprox	Acute: 0.04 (2007 PF) Acute: 0.15-0.44 Chronic:0.47-2.04 (2008) Acute:0.01 Chronic: 0.01 (2010)	Acute: Not calculated Chronic: No data 2007 PF, 2008, 2010).	Acute: 0.19 (2007 PF) Acute: 0.05-1.48 Chronic: 1.59-6.88 (2008) Acute: 0.04 Chronic: 0.04 (2010)	Not calculated (2007 PF). Acute: 21-63 Chronic: 68-293 (2008) Acute: 1.8 Chronic: 1.8 (2010)
Fenpropathrin *	Acute: 0.06-1.4 Chronic: 0.6-11.6 (2008)	Acute: 0.07-1.0 Chronic: no data (2008)	Acute: 0.3-5.9 Chronic: 0.9-17.6 (2008)	Acute: 2.7-150 Chronic:4.7-94 (2008)
Flumethrin	Not calculated (2016)			
Imiprothrin	Not calculated (2006)			
Momfluorothrin	Not calculated (2014)			
Permethrin*	Acute:0.68-6.73 Chronic:0.3-3.4 (2009) Acute: 0.06-6.96 Chronic: 0.14-61.17 (2008 ESA)	Acute: 0.25-2.42 Chronic:0.1-1.23 (2009) Acute: 0.02-2.50 Chronic: 0.05-21.97 (2008 ESA)	Acute: 5.4-53.2 Chronic:4.1-33.9 (2009) Acute: 2.11-59.43 Chronic:6.66 - 3271.43 (2008 ESA)	Acute: 29.0-280.0 Chronic: 9.1-120 (2009) Acute:2.48-305.56 Chronic:7.77-3816.67 (2008 ESA)
Prallethrin	Acute: <0.01 -0.06 Chronic:0.02-0.03 (2014)	Acute: <0.01-0.03 Chronic: 0.01 (2014)	Acute: <0.01-10.95 Chronic: <0.01-0.89 (2014)	Acute: 0.05-19.47 Chronic:1.40-1.42 (2014)

Active Ingredient	Freshwater Fish	Estuarine/Marine Fish	Freshwater Invertebrate	Estuarine/Marine Invertebrate
Pyrethrins*	Agricultural uses: Acute:0.07-0.54 Chronic:0.04-0.19 Mosquito uses: Acute: <0.00-0.04 Down the Drain: Acute: <0.00 (2006)	Agricultural uses: Acute:0.02-0.17 Chronic:0.01-0.06 Mosquito uses: Acute: <0.00-0.04 Down the Drain: Acute: <0.00 (2006)	Agricultural uses: Acute:0.03-0.24 Chronic:0.17-0.7 Mosquito uses: Acute: <0.00-0.02 Down the Drain Acute: <0.00 (2006)	Agricultural uses: Acute: 0.25-1.98 Chronic: 1.5-6.0 Mosquito uses: Acute: 0.02-0.95 Down the Drain: Acute: 0.02 (2006)
Tau-fluvalinate	Acute: 0.07-1.3 Chronic:1.4-2.2 (2005)	Acute: 0.02-0.04 Chronic:2.5-3.9 (2005)	Acute: 0.8-1.5 Chronic:3.6-4.3 (2005)	Acute: 12.5-23 Chronic: no data (2005)
Tefluthrin	Acute: 0.55 Chronic: Not calculated (1987) Acute: <0.01 Chronic: <0.01 (2010) Acute: 21 Chronic: 75 (2016)	Acute: Not calculated Chronic: Not calculated (1987) Acute: <0.01 Chronic: <0.01 (2010)	Acute: Not calculated Chronic: 3.8 (1987) Acute: <0.01 Chronic: <0.01 (2010) Acute: 18 Chronic: 32 (2016)	Acute: 0.62 Chronic: Not calculated (1987) Acute: <0.01 Chronic: <0.01 (2010)
Tetramethrin	Not calculated (2010)	Not calculated (2010)	Not calculated (2010)	Not calculated (2010)

* Risks to aquatic organisms were newly assessed in the 2016 current assessment for these chemicals (bifenthrin, cypermethrin, cyfluthrin, deltamethrin, esfenvalerate, fenpropathrin, cyhalothrin (lambda), permethrin, and the pyrethrins), described in the previous section. Therefore, only RQ's from assessments referenced in the problem formulations are cited above for these nine chemicals, and new use assessments since the problem formulations are not included. For the chemicals not assessed in the new 2016 assessment, RQ's are shown from assessments referenced in the problem formulations and from assessments completed since the problem formulations, where available.

Bird Risk Quotients

Active Ingredient	Acute	Chronic
Bifenthrin	Not calculated (2007) 0.04 – 0.11 (2012 ESA)	Not calculated (2007) 0.7 - 3.0 (2012 ESA)
Cyfluthrins	0 – 0.01 (2004) Zero (2006) Not calculated (2013 ESA)	0.01 – 0.24 (2004) Zero (2006) 0.03-12.1 (2013 ESA)
Cyhalothrin (gamma)	See lambda-cyhalothrin	See lambda-cyhalothrin
Cyhalothrin (lambda)	<0.1 – 0.2 (2002) Not calculated (2006)	<0.1 – 2.5 (2002) Not calculated (2006)
Cypermethrin(ANSI)	<0.01 – 0.08 (2008)	0.01 – 0.21 (2008)
Cypermethrin-alpha	Not calculated (2012)	0.02-0.62 (2012)
Cypermethrin- zeta	≤0.01 (dietary) <0.01-0.02 (dose) (2006) 0-0.04 (2013)	0.03-0.63 (dietary) (2006) 0.06-1.01 (2013)
Cyphenothrin	Not calculated (2009)	Not calculated (2009)
Deltamethrin	<0.1 - <0.74 (2013 ESA)	2.34 (2013 ESA)
d-Phenothrin	0 – <0.08 (2012)	Not calculated (2012)
Esfenvalerate	0.08 – 0.29 (dose) <0.01 – 0.01 (dietary) (2008 ESA)	0.27 - 2.75 (2008 ESA)
Etofenprox	Not calculated (2008, 2010)	Not calculated (2008, 2010)
Fenpropathrin	0 – 0.02 (2008) <0.10-0.36 (2013)	2.3 – 7.0 (2008) 0.13 - 7.48 (2013)
Flumethrin	Not calculated (2012)	Not calculated (2012)
Imiprothrin	Not calculated (2011)	Not calculated (2011)
Momfluorothrin	Not calculated (2014)	Not calculated (2014)
Permethrin	Not calculated (2008 ESA) <0.01 – 0.03 (2009 RED)	<0.01-19.78 (2008 ESA) 0.04 – 0.59 (2009 RED)
Prallethrin	<0.01 (2014)	<0.01 – 0.01 (2014)
Pyrethrins	0.0 – 0.02 (2006 RED)	0.01 – 0.78 (2006 RED)
Tau-fluvalinate	<0.01 – 0.06 (2005 RED)	<0.01 – 0.36 (2005 RED)
Tefluthrin	0.015 – 0.925 (2010) 0.46 (2016)	318.11 (2010) <0.01-3.14 (2016)
Tetramethrin	Not calculated (RED)	Not calculated (RED)

Mammal Risk Quotients

Active Ingredient	Acute RQ's	Chronic RQ's
Bifenthrin	Not calculated (2007) 0.01 - 1.84 (2012 ESA)	Not calculated (2007) 65.95 (dose-based)\ 7.60 (dietary-based) (2012 ESA)
Cyfluthrins	0.5-0.89 (2004) 0-1.0 (2006) 0.02 – 2.84 cotton 0.1 – 16.23 airports (2013 ESA)	< 1 (2004) 0-0.01 (2006) 0.13 – 2.12 cotton 0.31 – 48.7 airports (2013 ESA)
Cyhalothrins (gamma)	See lambda cyhalothrin	
Cyhalothrins (lambda)	< 0.01 to 1.26 (2002)	< 0.1 to 2.5 (2002)
Cypermethrin (ANSI)	< 0.01-0.19 (2008)	0.04-9.27 (dose-based) (2008)
Cypermethrin-alpha	<0.01 -0.16 (dose-based) (2012)	< 0.01-2.71 (dose-based) (2012)
Cypermethrin- zeta	<0.01 -0.16 (dose based) (2006) 0.001-0.26 (2013)	0.01-2.73 (dose-based) (2006) 0.03-4.39 (dose-based) (2013)
Cyphenothrin	RQ's not calculated	
Deltamethrin	<0.1 - 6.81 (2013 ESA)	1.31- 84.51 (2013 ESA)
d-Phenothrin	RQ's not calculated (2008) 0-0.01 (2012)	0-0.001 (2008) ≤ 0.01 (2012)
Esfenvalerate	0.09 – 0.90 (2008 ESA)	1.24 – 12.62 (2008 ESA)
Etofenprox	Zero (2007) RQ's not calculated (2008, 2010)	Zero (2007) RQ's not calculated (2008, 2010)
Fenpropathrin	0.0-0.02 (2008) < 0.01-1.6 (2013)	2.3-7.0 (2008) 0.2-26.0 (2013)
Flumethrin	RQ's not calculated	
Imiprothrin	RQ's not calculated	
Momfluorothrin	RQ's not calculated	
Permethrin	<0.01-7.05 (2008 ESA) < 0.01 – 0.04 (2009)	0.01- 387.3 (2008 ESA) 0.01-0.30 (dietary based); 0.01-2.57 (dose based) (2009)
Prallethrin	<0.01 (dose and dietary based) (2014)	<0.01 (dose and dietary based) (2014)
Pyrethrins	< 0.01 – 0.06 (2005)	0.04-0.97 (2005)
Tau-fluvalinate	< 0.5 (2005)	2.12-74.18 (2005)
Tefluthrin	0.43 – 16.45 (2010) <0.01 – 0.75 (2016)	159.05 (2010) <0.02-13.62 (2016)
Tetramethrin	RQ's not calculated	

Appendix C. D-Phenothrin Down the Drain Uses

Qualitative Assessment of Potential Risks to Aquatic Organisms from Down-the-Drain Releases of d-Phenothrin when Coformulated with Antimicrobial Active Ingredients (Jennings, Pat; August 17, 2016).

STERI-FAB, EPA Registration number 397-13, has both conventional and antimicrobial pesticide applications. This product serves as a bactericide, sanitizer, fungicide, mildewcide, insecticide, deodorant, and viricide. STERI-FAB contains 0.22% d-Phenothrin as an active ingredient. Since the Agency was concerned about the potential for d-Phenothrin to be released down-the-drain as a result of the use of STERI-FAB, the Agency required data to determine the fate and effects of d-Phenothrin to wastewater treatment plant microorganisms.

The Agency required the following studies:

- A study on biodegradation of d-Phenothrin during wastewater treatment;
- A study on sorption of d-Phenothrin during wastewater treatment; and
- A study on toxicity of d-Phenothrin to activated sludge microorganisms.

The purpose of these tests was to determine toxicity of d-Phenothrin to activated sludge microorganisms and to determine the percent removal of d-Phenothrin during wastewater treatment. Information on percent removal of d-Phenothrin during wastewater treatment is required as an input to the Down-the-Drain module of E-FAST to perform a quantitative assessment of potential risks to aquatic organisms downstream of domestic wastewater treatment plants to which d-Phenothrin is discharged.

The Agency reviewed these studies and concluded that d-Phenothrin would not be expected to be highly toxic to activated sludge microorganisms, would strongly sorb to activated sludge, and would not readily biodegrade during wastewater treatment. To measure adsorption to sludge, the Agency received an estimate of the adsorption coefficient (Koc) based on High Performance Liquid Chromatography (HPLC) simulation (OECD Guideline Number 121) instead of the required ASSI study (OCSPP 835.1110). The estimated log Koc from OECD 121 was 5.1 within a 95% confidence interval range of 4.4 to 6.9. This estimate did not allow for the calculation of percent removal which is needed for quantitative modeling, but the estimate was consistent with what is known regarding the environmental fate of d-Phenothrin. Based on results from these studies, much of d-Phenothrin that might enter a wastewater treatment plant would be expected to be removed by sorption to activated sludge. In addition, the amount of d-Phenothrin that would be expected to be used in antimicrobial applications is very low. Consequently, potential risks to aquatic organisms downstream of domestic wastewater treatment plants that might receive d-Phenothrin from antimicrobial sources released down-the-drain would be expected to be negligible.